1976 COOPERATIVE WESTERN SPRUCE BUDWORM CONTROL PROJECT

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ERRATA SHEET

Page A-15: Okanogan, Sevin 4 Oil Abbotts Mortality should be .922 instead of .722.

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COVER: *Large Bell 205-A helicopters were used for spraying some areas.*

1976 WESTERN SPRUCE BUDWORM CONTROL PROJECT

Table of Contents

1976 WESTERN SPRUCE BUDWORM

CONTROL PROJECT

Abstract

A total of 365,702 acres infested with western spruce budworm was treated in Oregon and Washington during 1976. Of this total, 7,663 acres were treated with Sevin 4 Oil at the rate of 1 pound (AI) in ½ gallon of formulated material per acre, and 358,039 acres were treated with ultra low volume Malathion at the rate of 13 ounces of technical grade material per acre.

A total of 23 helicopters and 2 fixed-wing aircraft was used in applying the insecticide. In addition, 13 helicopters and 1 fixed-wing aircraft were used for observation and general administration of the project. A total of 1,558 flying hours occurred during the project with no accidents or injuries.

Environmental monitoring of fish, aquatic organisms, birds and bees revealed no adverse effects of the treatment with the exception of a temporary reduction in aquatic organisms in streams which were directly treated with insecticide. Where one-swath width buffer zones were left along streams, no significant difference in aquatic insect drift was noted.

The uncorrected insect mortality for the project averaged 82.3 percent for the area treated with malathion. Corrected for natural mortality, this overall mortality decreased to 64.2 percent. The uncorrected and corrected insect mortality for the Sevin 4 Oil-treated area was 96.2 and 92.2 percent, respectively. It may be necessary to retreat about 100,000 acres during 1977.

The total cost of the project was $1,696,853 or $4.64 per acre. Of this total, costs to private landowners were $56,436, to the State of Washington was $63,208, and the remainder was paid for by the Federal government.

I. INTRODUCTION

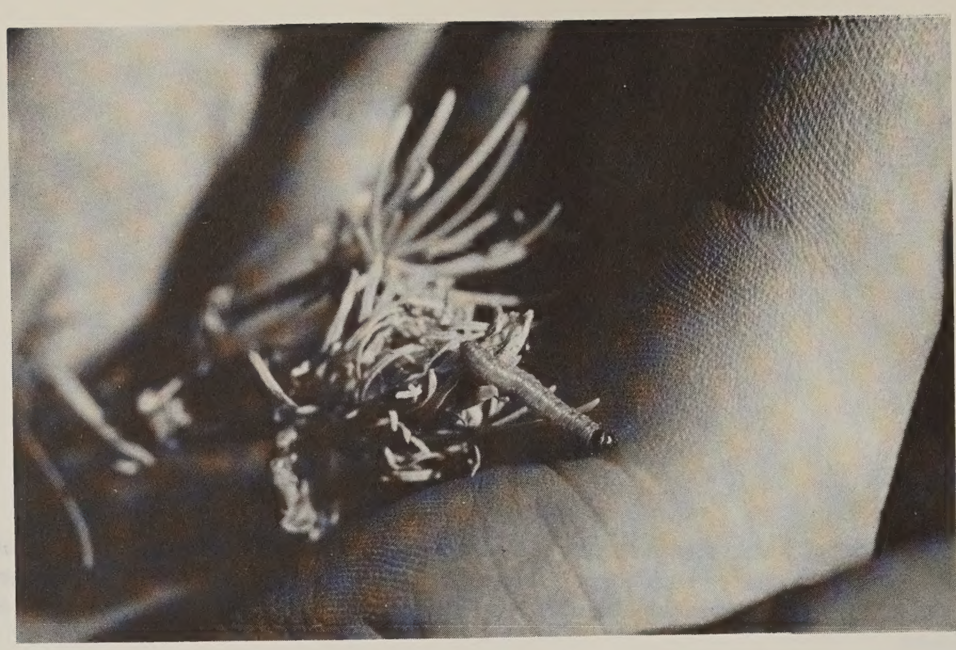
The first major spruce budworm infestation in Washington was reported in 1943 in the Methow Valley. During the period from 1943 to 1964, visible budworm defoliation was observed annually in Oregon and Washington. For a 5-year period, from 1965 to 1970, budworm populations subsided to a level where no visible defoliation was observed in either State.

After being absent for 24 years the western spruce budworm (*Choristoneura occidentalis*) was discovered again in north-central Washington in the summer of 1970. In 1971 surveys indicated that about 18,000 acres in Washington and 28,000 acres in Oregon suffered some degree of defoliation. By 1975 the infested acreage had increased to 532,000 acres, of which 19,000 acres occurred in Oregon.

II. THE INSECT

The preferred host species of the western spruce budworm are Douglas-fir, grand fir, Engelmann spruce, and Pacific silver fir. Other species that may sustain some damage when growing in association with the preferred hosts are subalpine fir, western larch, and several species of pines.

Western spruce budworm normally develops from egg to adult in 12 months, but some may require 24 months to complete their life cycle. Adult moths emerge from pupal cases in late July or early August. Shortly afterwards the females deposit approximately 150 eggs in egg masses which average 25 to 40 eggs each. The eggs hatch in about 10 days and the newly hatched larvae do not feed but seek hiding places among lichens or under bark scales on the host trees. During their search for a hiding area the larvae molt to the second instar. After locating a hiding place they spin silken shelters (hibernacula) and remain dormant through the winter. In the spring, larvae leave their silken shelters and move out towards the foliage where they tunnel into old needles and feed for 7 to 14 days. When the buds start to swell, the larvae leave the needles and bore into the expanding buds. Some larvae, however, move directly from hibernation to vegetative buds or male or female flowers. As new shoots unfurl, the larvae spin loose webs between needles and tips and feed on new foliage within the webs. Large larvae usually finish feeding on current needles, even though their earlier feeding may have included staminate flowers and conelets.



Large larvae finish their feeding cycle on current needles.

Larvae become full-grown in 30 to 40 days after leaving hibernacula and pupate either in existing webs or webs they spin elsewhere on the tree. They remain in the pupal stage for 7 to 14 days before the adult moths emerge. Adult moths are sluggish fliers but may be carried great distances by air currents. Females deposit eggs within 7 to 10 days and then die.

III. BIOLOGICAL EVALUATION

An evaluation of the budworm population and of the damage caused by the budworm was made in the fall of 1975 by Forest Service and State of Washington entomologists to determine if the outbreak was likely to continue and if direct control was necessary to prevent further damage to timber and related forest resources. The method used for this determination was as follows:

A. Egg Mass Density

The number of new eggs per 1,000 square inches of foliage was calculated for each sample plot. Based on this density, a defoliation prediction for 1976 was made using the following values established by Carolin and Coulter (1972), and assigning an egg mass density code to be used in hazard rating the plot. The density code is as follows:

Egg Masses Per 1,000 Sq. Inches	1976 Predicted Defoliation	Density Code
0.0 - 1.3	Very Light	0
1.4 - 3.5	Light	1
3.6 - 8.9	Moderate	3
9.0 - 17.7	Heavy	5
17.8 or more	Very Heavy	7

B. Defoliation Hazard Code

The defoliation hazard code was determined by summing separately the new and old defoliation intensity codes from each of the crown thirds. The total was then converted to a single number for both the new and old defoliation using the following scale:

Defoliation Intensity Code		Defoliation Category	Defoliation Hazard Code	
Old	New		New Foliage	Old Foliage
0 - 1	0 - 1	Very Light	0	1
2 - 4	2 - 8	Light	1	3
5 - 7	9 - 15	Moderate	3	5
8 - 10	16 - 21	Heavy	4	7
11 - 12	22 - 27	Very Heavy	6	9

The hazard index was calculated by summing the egg mass density code and the two defoliation hazard codes. The result is a single number or hazard index. The higher the hazard index, the greater the danger to the affected trees. An index higher than 16 indicated top-killing and tree killing was likely to occur in 1976. An index higher than 10 indicated that almost total growth loss would occur during 1976.

Treatment recommendations were based on both the computed average hazard index and the average egg mass density for the sample area. Units containing an overall average of four or more egg masses per 1,000 square inches of foliage and an average hazard index of 10 or higher were recommended for treatment.

The use of this system insured that high-hazard stands with egg mass levels sufficient to cause tree mortality, top-killing, and/or growth loss would be treated.

Analysis of the data collected from 410 plots in Oregon and Washington indicated that the number of acres on which the new egg masses exceeded the damage threshold of four egg masses per 1,000 square inches of foliage and the old defoliation index was 10 or higher was 291,000 acres.

C. Overwintering Survey

Branch samples were collected in January 1976 to measure overwintering budworm population in 11 areas that were not sampled in the fall of 1975 due to limited accessibility and available time. A total of 522 branches were collected from 87 plots. The amount of defoliation on each sample tree on all plots was also determined. The branch samples were placed in individual containers until hibernating larvae emerged and were then counted. Areas meeting the treatment criteria of six larvae per 100 square inches of bark surface and old defoliation index of five or higher were added to the treatment program. Five of the 11 areas, totaling 27,000 acres, qualified for treatment and were included in the 1976 treatment recommendations. The method used for making this determination was as follows:

1. Budworm Population Survey

   Budworm evaluation plots were located in all areas where additional information was needed. Data was collected at each plot during January on budworm numbers and degree of defoliation in 11 areas. Number of plots ranged from two to 13 per area. Each plot consisted of three trees, either Douglas-fir or true fir.

   Two mid-crown branches were collected from each tree. Three, 15-inch sections were taken from the bole end of each sample branch. These six branches were placed in a plastic bag and transported to the laboratory in Portland. Samples were not allowed to reach temperatures more than a few degrees above freezing during transportation. At the laboratory, the area of bark surface was determined and the samples were placed in a 5-gallon paperboard carton and completely sealed. These cartons were then placed in a rearing room with a glass vial placed in the end of each carton. Lights were shown on the vials day and night and temperatures maintained between 65° and 75° F. during rearing period. The newly emerged larvae migrated into the vials and were counted for each tree. This count was then converted to larvae per 100 inches of bark surface.

2. Defoliation Hazard Survey

   At the same time the branch samples were collected, each sample tree was rated as to past (1971-74) and current (1975) degree of defoliation. The procedure followed in rating the defoliation was exactly the same as used during the egg mass evaluation survey conducted earlier in the fall.

3. Evaluation Procedure

   The average number of overwintering budworm larvae per 100 square inches of bark surface was computed for each tree and plot. Areas having six or more larvae per 100 square inches of bark surface were considered to have budworm populations high enough to be considered as damaging.

   The criteria of six larvae per 100 square inches was based on the population data collected in 1975 in the same general area. Surveys of that population showed that six or more overwintering larvae per 100 square inches of bark surface resulted in populations well in excess of the five feeding larvae per 100 buds established as a minimum level for control (Carolin and Coulter, 1971).

   The defoliation hazard code was determined by the same procedures used during the fall egg survey. This was done by summing separately the new and old defoliation intensity codes from each of the tree crown thirds. The total was then converted to a single number for both the new and old defoliation using the following scale:

Intensity Code*	Category	Defoliation Hazard Code
0 - 1	Very Light	1
2 - 8	Light	3
9 - 15	Moderate	5
16 - 21	Heavy	7
22 - 27	Severe	9

** Old Defoliation Only*

   A total of 318,700 infested acres met or exceeded the treatment criteria and were considered for treatment during 1976.

IV. ENVIRONMENTAL STATEMENT

In the fall and winter of 1975-76, a Draft Environmental Statement was prepared in cooperation with the Washington State Department of Natural Resources and the Bureau of Indian Affairs. The Draft Statement proposed suppression of the spruce budworm infestation on the most severely damaged areas by treatment with Sevin 4 Oil, Dylox, or malathion or a combination of the three. The alternatives considered were chemical control with DDT; chemical control with Zectran; chemical control with other insecticides; biological control including parasites and predators; bacterial diseases, sex attractants, and juvenile hormones; cultural methods; and no action.

The Draft Statement was filed with the Council on Environmental Quality on January 30, 1976. A total of 30 responses to the proposed action were received during the review period which was completed on March 30, 1976.

The Final Environmental Statement proposed to treat 318,700 acres of infested area with malathion and 7,600 acres with Sevin 4 Oil. The decision to treat the

bulk of the area with malathion was based on previous project treatment effectiveness and benefit/cost considerations. A smaller area was to be treated with Sevin 4 Oil, which was registered in 1976 for use against the western spruce budworm, as a comparison with malathion.

The Final Environmental Statement was filed with the Council on Environmental Quality on May 3, 1976.

Acreage figures were adjusted from those given in the Environmental Statement prior to treatment when treatment areas were actually located on the ground. The net acreage requiring treatment was generally found to have been underestimated. The final acreage treated was about 38,000 acres greater than originally planned.

V. PROJECT PLANNING AND PREPARATION

In the early spring of 1975, when it was determined that the spruce budworm infestation was likely to require direct treatment, a Spruce Budworm Steering Committee consisting of representatives from the Wenatchee and Okanogan National Forests, the Washington State Department of Natural Resources, the National Park Service, the Bureau of Indian Affairs, and the major private landowners in the infested area, was formed.

After reviewing the results of the 1975 Fall Egg Mass Survey, the Committee made the decision that a major control project should be considered in 1976 and that an environmental statement should be prepared.

From information presented in the environmental statement, the Steering Committee decided that malathion should be the primary control agent on the basis of existing efficacy data and a more favorable benefit/cost ratio. They also decided to use Sevin 4 Oil on part of the area in order to compare the relative effectiveness of the two chemicals in controlling the spruce budworm. These were the only two chemicals that were currently registered against the western spruce budworm.

A. Operational Plans

In order to properly prepare application and insecticide contracts and recruit personnel it was necessary to make some project organizational decisions as early as March 1. It was decided to divide the project area into three control units with headquarters at Twisp, Cashmere, and Ellensburg, Washington. In addition, a central project headquarters was set up at Cashmere to coordinate the entire project. The Warm Springs Indian Reservation in Oregon was handled as a Subunit of the Ellensburg Control Unit. The Ellensburg Unit was administered by the Washington State Department of Natural Resources. The Okanogan Unit, headquartered at Twisp, and the Wenatchee Unit, headquartered at Cashmere, were administered by the Forest Service. Overall coordination was under the direction of a Forest Service Project Director. The administrative organization of each control unit is shown in the Organization Charts in the Appendix.

A central Project Headquarters was set up at Cashmere, Washington to coordinate the entire project.

Personnel for the project were recruited from almost every National Forest in Oregon and Washington as well as from several Washington State Department of Natural Resources Districts. Many were personnel who had gained experience in this type of project on the 1973 and 1974 tussock moth projects in eastern Oregon and Washington, or on the 1975 Spruce Budworm Pilot Project on the Okanogan National Forest in Washington. A total of 123 people worked directly on all phases of the control project including environmental monitoring, excluding contractors. Of the total permanent and temporary personnel directly involved in the project, 79 were Forest Service personnel, 35 were Department of Natural Resources personnel, and 9 were Washington Department of Ecology monitoring personnel.

Three meetings were held with key project personnel in March, April and May to work out details of organization and operational aspects of the project. Training sessions for project personnel were planned and dates set. Meetings were held with the Steering Committee to determine the role of the large private landowners and the two National Forests in the project.

B. Contracting

Separate contracts were awarded in April and May for the following items or services:

1. Insecticide.
2. Transportation and storage of insecticide.
3. Application by helicopter and/or fixed-wing aircraft.
4. Helicopter observation and administrative flight time.
5. Environmental monitoring of fish, aquatic insects, and water.
6. Rental of vehicles.

American Cyanamid Company was awarded the contract for malathion. A total of 33,000 gallons was delivered in tank cars at or near Wenatchee, Washington at the bid price of $9.94 per gallon. An additional 1,000 gallons was purchased in bulk and 2,900 gallons were purchased in drums at a cost of $10.04 per gallon. Total cost for malathion was $366,654 for insecticide.

1. Insecticide furnished was Malathion ULV concentrate, 95 percent technical grade, in bulk, delivered in railroad tank cars and/or tanker truck trailer conveyance.
2. Contractor was responsible for all additional cost at F.O.B. destination for demurrage, and obtaining a railroad siding for storage of insecticide prior to unloading.
3. Contractor agreed to accept return of any unused insecticide returned F.O.B. contractor's plant or other destination at a cost of $.50 per gallon. No insecticide was returned.

A contract for unloading and transportation of government-furnished insecticide and facilities for the storing and loading of the insecticide into the aerial spray contractor's tank trucks at Twisp and Ellensburg, Washington was awarded to Chempro of Oregon, Inc. for $22,722.84 to handle an estimated 25,400 gallons. The significant features of this contract were:

Insecticide storage tanks were located at Cle Elum Airport and Twisp, Washington.

1. Contractor furnished all equipment, transportation, storage, labor, and incidentals necessary for transportation and storage.
2. Contractor was required to have not less than 1,500 gallons or more than 5,000 gallons of insecticide on hand and ready for use at each of the designated locations 3 days after notice to proceed.
3. Contractor was permitted to use either stationary or mobile storage tanks as long as the minimum insecticide requirements were met and the facilities used were compatible with the other loading facility requirements.

Except for one small business set-aside, the contracts for application of the insecticide were awarded to a number of firms on the basis of competitive bidding. Original bid quantities, unit prices, and actual payments under the applicator contracts are shown on the applicator contract summary chart (Appendix). Two contractors failed to meet the contract requirements and were replaced. Replacement contractors are also shown on the summary chart.

Significant features of the application contracts were:

1. Payments were made on the basis of total gallons sprayed. Increase or decrease of sprayed acres of less than 25 percent of those designated in the bid would not constitute a basis for adjustment of the contract unit price.
2. Contractor to provide transportation of spray solutions from the three designated storage facilities (one in each Unit) to operating heliports or airports.
3. Spray helicopters to have performance equal to or better than a Bell 47 G3B-1 or Hiller 12E equipped with dual carburetors and hi-dome pistons.
4. Fixed-wing aircraft to be single engine, with engine horsepower in the range from 230 to 600 and manufactured and configured exclusively for aerial application work.
5. Application of spray to be confined to designated areas at a rate of 13 ounces per acre. A buffer zone of one-swath width was to be left unsprayed on each side of designated streams.
6. Spray application heights to be within the range of 40 to 60 feet above ground cover when terrain and safe flying practices permitted. This requirement was changed to 100 feet for fixed-wing aircraft.
7. Nozzle systems to be capable of applying spray material at a rate of 13 ounces per acre with an average droplet size of 150 microns, volume median diameter (VMD).
8. Three Subunits on the Ellensburg Control Unit were open to bidding by either fixed-wing or rotary-wing aircraft because of flatter topography. All other Subunits were to be rotary-wing aircraft only.
9. No spraying to take place when wind speed exceeded 6 miles per hour, brush was wet or covered with snow, or it was raining.

Fixed-wing aircraft were used for application on areas of flatter topography.

Helicopter service contracts were also awarded for observation of spraying and administrative flying on the basis of competitive bidding.

A summary of these service contracts is found in Table 9. Services which the nonspray aircraft were generally required to perform included ferrying of insect sampling crews, locating treatment boundaries, observation of aerial spraying, general administrative flights, search and rescue missions, and hauling cargo.

The purpose and intent of the contract was to provide the services of light turbine-powered helicopters for use in observation of aerial spraying and other project activities during the designated availability period.

Significant features of the helicopter service contracts were:

1. During the designated availability period, helicopters must be available for use at all times as specified by the contracting officer, fully operational and ready for takeoff.
2. One service truck, attended by a helper or the certified mechanic, was required for each helicopter.
3. Minimum helicopter specifications were as follows:
   a. Be four-place (except for the headquarters' helicopter which had to be five-place).
   b. Capable of hovering in ground effect at 5,000 feet MSL at 25°C with a payload of 550 pounds (headquarters' ship 680 pounds), as determined by standard Forest Service helicopter loading instructions using actual pilot weight and fuel for 2 hours (headquarters' ship, 2 hours and 30 minutes).
4. Payment was to be on the basis of flight hours and daily availability. The hourly flight rate with pilot was $175.00 per hour for all ships except the headquarters helicopter which was $160.00 per hour (without pilot). Daily availability was the basis for bidding. Availability was to be paid every day from the time the helicopter was ordered to start work until the contract was terminated. Fifteen days of availability were guaranteed.

Each spray aircraft was accompanied by an observation aircraft with a trained aerial observer.

A contract for environmental monitoring of fish, aquatic organisms, and water quality was awarded to the Washington Department of Ecology. Significant features of this contract were:

1. Determine the incidence of malathion or Sevin 4 Oil in the aquatic environment through sample analysis.
2. Assess the impacts, if any, of malathion or Sevin 4 Oil on aquatic organisms including, but not limited to, benthic invertebrates and native fish.
3. Provide samples of certain nontarget organisms to the Department of Social and Health Services Pesticide Laboratory, Wenatchee, Washington, for analysis.
4. Provide results of these investigations to the Forest Service in the form of a final report by January 15, 1977.

The total bid price for this contract was $35,500.

A contract for project vehicles was added to the regular Wenatchee National Forest vehicle contract. Twenty-eight vehicles were leased by the Forest Service and 17 vehicles by the Washington State Department of Natural Resources (DNR). Contract prices ranged from $300 to $700 per month depending on type vehicle, contractor, and period of use.

C. Training

Training sessions were held for project personnel at various times prior to the start of the project. In May, all Spray Operations Officers and the Forest Service C.O.R. on the Ellensburg Control Unit attended a 2-day training session on aircraft calibration conducted by the Methods Application Group in Davis, California. That same month, Aerial Observers, Heliport Managers, and Safety Officers attended a 3-day school in Seattle on Aerial Operations Safety. All project personnel were also given training in their individual job requirements and temporary crews were given vehicle driver training before they started work in June. Safety training was given to each individual before the beginning and at intervals throughout the project. Many individuals had experience on previous aerial spraying projects and could be used as instructors for the inexperienced personnel. This contributed substantially to the success of the operational phases of the project.

VI. SPRAY OPERATIONS

A. Adjustment of Spray Boundaries

Treatment area boundaries were located by helicopters early in June. Mapped Unit boundaries were adjusted to easily recognizable topographic, timber type, and infestation boundaries. Boundaries not easily recognizable from the air were marked with highly visible fluorescent orange streamers from the air or on the ground. These consisted of large panels (3 feet by 6 feet) spread flat in openings and anchored with rocks.

B. Spray Block Boundaries

Spray blocks were laid out on aerial photos or topographic maps on the basis of elevation and aspect. The objective was to have insects in each spray block develop at about the same rate. In a few cases the original boundaries were found to include too large a difference in elevation and were later divided before treatment.

C. Development and Evaluation Plots

In order to determine when insects were at the stage of development when they were most susceptible to the insecticide (50 percent in the fifth or sixth instar), insect development plots were located in each spray block. Release of the block for spraying was based on the results of data collected from periodic examination of these plots. Generally there was one development plot in each spray block. Blocks with a large difference in elevation might have more than one plot to measure the differences in development. Other blocks with poor access contained no plots. In these cases, development was interpolated from the nearest plot at the same elevation and aspect.

Since many areas included in the project were unroaded and walking time was prohibitive within the time limits available, helicopters were used to ferry crews to and from sample plots.

After spray block boundaries had been determined and marked on aerial photos, marking of boundaries was done from the air, mostly by helicopters. Boundaries were marked with fluorescent orange ribbon as in the case of the exterior spray boundaries. A total of 26 evaluation plots were installed in each subunit for determining the effectiveness of the treatments. Each plot consisted of three trees, 30 to 50 feet tall with some recent defoliation. Evaluation plots were scattered throughout the subunit on a random basis where access permitted.

D. Release of Spray Blocks for Treatment

Spray block boundaries were marked to be easily visible to the spray pilots. Insect development plots were sampled by cutting two, 15-inch bud bearing branches from opposite sides of the mid-crown of each sample tree. Number of open and unopened buds were counted from each sample. All budworm larvae were collected and brought to headquarters where the instar was determined by an entomologist or other well-trained personnel. The percentage of those that had reached the fifth and sixth instar was calculated. The Unit Entomologist released a block for spraying as soon as at least 50 percent or more insects had reached the fifth instar or larger, including pupae, and the buds had unfurled. Where data appeared to be inadequate, the Unit Entomologist or his assistant made on-the-ground examinations before the block was released.

Branches were collected from mid-crown of sample trees.

Larvae were removed from branches collected from sample trees.

Larval instars were determined by entomologists.

If weather or operational problems prevented spraying of any blocks before 5 percent of the budworm had pupated, the block was not treated. This occurred on three spray blocks on this project.

E. Treatment

A total of 358,039 acres were treated with Malathion ULV concentrate at 13 ounces per acre. An additional 7,663 acres were treated with Sevin 4 Oil at 1 pound AI in ½ gallon of No. 2 fuel oil per acre for a total of 365,702 acres treated.

The number of acres treated within each of the three Control Units and their Subunits are shown in Table 6 and illustrated charts 1 and 2. A breakdown by ownership is shown in Table 4, Appendix. Because of an abnormally cold and wet spring, spraying did not begin until June 27. The first blocks to be treated were located on the Wenatchee Unit. Spraying on the Ellensburg Unit began on June 29 and on the Okanogan Unit on June 30. After June 28, only 1 day was lost on all Units because of weather, but several Units lost days individually because of rain, wind, or low temperatures (see Table 6, Appendix). Spraying was completed on July 24.

Topographical features on the three Control Units varied from moderately rough to extremely rough ridges and canyons. Most of the Wenatchee and Okanogan Units and part of the Teanaway Subunit of the Ellensburg Unit were extremely rough. Elevations ranged from 3,000 to 7,000 feet above sea level.

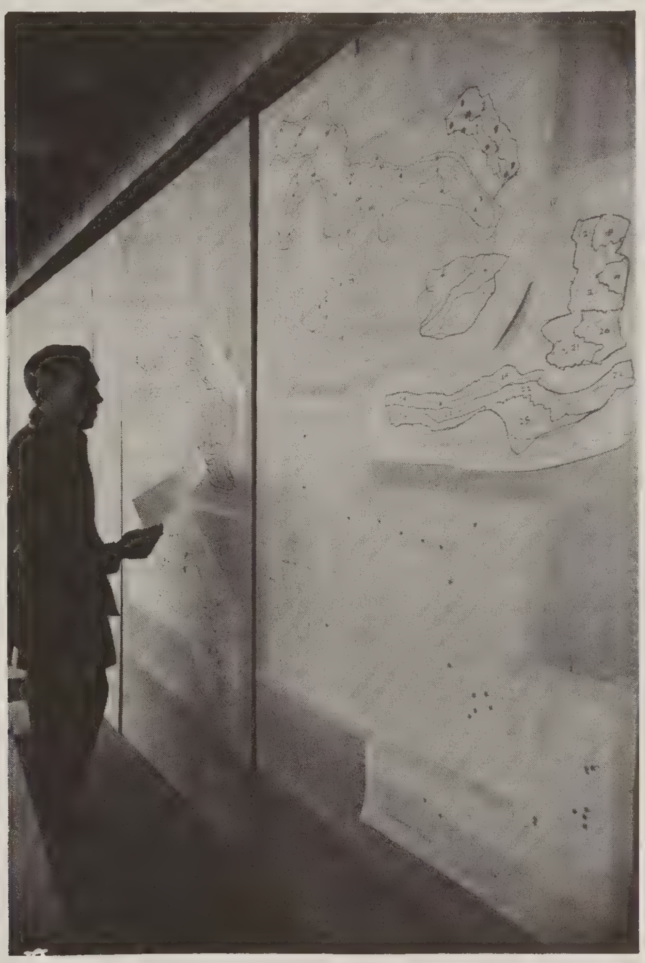
Heliports were located in natural openings such as meadows, open ridgetops, clearcuts, rock outcrops, or roadways that were accessible to tank trucks. Forty-five heliports and two airports were utilized on the three Control Units.

Each contract helicopter was inspected by Project Air Officers for airworthiness, contractual specifications, and suitability for the work. They also checked the qualifications and proficiency of contract pilots.

Approximately 557 flight hours were required to treat the three Control Units for an average production rate per flight hour of 657 acres (see Table 7 Appendix). The greatest production occurred on July 14 when the three Control Units treated 36,434 acres. During the period of July 9 to July 16 when the Ellensburg Unit had a temporary shutdown for 5 days, the three Units treated 199,561 acres for a daily average of almost 25,000 acres. The greatest daily Unit production was by the Ellensburg Unit on July 14 when they treated 15,933 acres with five small helicopters.

The original successful contractors provided all small helicopters such as Bell 47 G3B-1's, Hiller 12E's, or airplanes. Two of these contractors were terminated during the project for nonperformance. One of the takeover contractors provided two 205-A helicopters and two Hiller 12E's and another provided a Bell 206-B equipped for spraying, as well as two Bell G3B-1's. The third original contractor with five Bell G3B-1's completed the Unit he had contracted for and provided two of his ships to assist in completing another Control Unit.

Observation and administrative aircraft flew a total of 1,002 hours. This time includes 62.5 hours in the fixed-wing observation aircraft. These ships were used for a wide variety of activities including locating heliports, ferrying personnel, inspections, hauling cargo, boundary marking, and spotting crews at or near plot locations. However, their primary function was to monitor the spray application. Field sampling crews were heavily dependent on helicopters for transportation to and from the development and evaluation plots. Observation aircraft-use summaries are shown in Table 9, Appendix.



Large-scale maps were used to delineate spray blocks and maintain record of areas treated.

F. Pesticide Spills

There were eight insecticide spills during the project. The first spill occurred on the Swauk Subunit of the Ellensburg Control Unit when a hose clamp slipped off the boom of a fixed-wing aircraft and spilled 20 gallons of malathion over a large area. The pilot was immediately instructed to return to the airport avoiding all population and other sensitive areas. On investigation by the Unit Environmental Coordinator, it was determined that because the chemical was spread over such a wide area, no clean up action would be effective and no environmental damage had occurred.

The second spill occurred on June 30 in Pekin Creek on the Okanogan Control Unit when a hose slipped off of the spray boom and spilled 35 gallons of malathion over a fairly large area. The Unit Environmental Coordinator who inspected the area decided that no environmental damage had occurred and no clean up action was taken.

The third spill occurred on July 3 on the Okanogan Unit when a hose slipped off the boom of a helicopter

at the heliport. Five gallons of material went into about 2 to 3 inches of water in an irrigation ditch running through the heliport. The spill was immediately dammed up with activated charcoal. The area was then covered with sawdust to absorb the water. When the water was absorbed, the charcoal and sawdust were removed to an approved pesticide disposal site. The Unit Environmental Coordinator who inspected the spill determined that there were no adverse environmental effects from the spill.

The fourth spill occurred on July 4 when a 2-inch hose line on a fixed-wing aircraft broke, spilling approximately 64 gallons of malathion on the Ellensburg Control Unit. The spray was forced out of the hose as a heavy fog which settled over a large area. The Unit Monitoring Coordinator determined that no clean up action would be effective and that no environmental damage had occurred.

The fifth spill took place on July 10 on the Okanogan Control Unit when a pilot inadvertently hit his emergency dump valve while working on his ship at a heliport. Approximately 17 gallons were spilled. The saturated ground was dug up and mixed with charcoal. The soil was then removed to an approved pesticide disposal site.

The sixth spill occurred on July 13 when an air pocket jarred the dump valve loose on a 205-A helicopter, dumping about 100 gallons of malathion on an area of steep rocky terrain on the Okanogan Control Unit. Investigation by the Unit Environmental Coordinator determined that the spill was not near water and was in an area where little adverse environmental effects would occur.

The seventh spill occurred on July 18 on block 56 of the Okanogan Control Unit when the emergency dump valve jarred loose on a 205-A helicopter spilling about 85 gallons of malathion. A small amount of the insecticide probably went into a small creek. Bags of activated charcoal were immediately placed in the creek downstream to filter insecticide from the water. The charcoal was later removed to an approved pesticide disposal site.

The eighth spill occurred on July 19 at heliport 16 on the Okanogan Control Unit when a hose came loose while loading a spray ship. Approximately 50 gallons of malathion were spilled. The area was immediately dug up and the contaminated soil placed in plastic bags. The material was hauled to an approved pesticide disposal site.

A total of 376 gallons of malathion was spilled accidentally on the project; 84 gallons on the Ellensburg Control Unit and 292 gallons on the Okanogan Control Unit. There were no spills on the Wenatchee Control Unit. Only one spill occurred in the vicinity of water or other critical areas and no adverse environmental effects occurred as far as is known. Prompt remedial action was taken on all spills and all were investigated by the Unit Environmental Coordinator on the concerned Control Unit. The EPA Regional Office in Seattle was notified of each spill incident.

G. Safety

All phases of safety were given special emphasis on this project. A Project Safety Officer was assigned who was a qualified Forest Service Fire Safety Chief and who had attended Regional Safety Workshops and the National Safety Training Session at Marana, Arizona. In addition, each Control Unit had a Unit Safety Officer whose primary duty was to promote safety and who was well-qualified in this field. The Project Safety Officer wrote the Safety Plan for the project and each Unit Safety Officer provided a Control Unit supplement. These personnel were responsible for all safety aspects of the entire operation.

A driver safety training program was held for all temporary personnel by a Regional Driver Training Instructor. The Regional Helicopter Specialist conducted safety training instruction for Heliport Managers at intervals throughout the project.

All personnel on the project were given special safety training for working in or around helicopters. Special attention was given to location and construction of safe heliports by Safety Officers, Spray Operations Officers, Helicopter Specialists, and Project Air Officers.

Even though more than 1,558 hours were flown in extremely rough topography and often under heavy air traffic conditions, there were no aircraft accidents. There was one serious vehicle accident which did occur when, during closure of a major highway on Swauk Pass to permit spraying, a car passed the rest of the traffic which had just been released and hit a project vehicle head on. The driver of the private car sustained serious injuries and was in the hospital for several days. The project driver, although shaken up, was not hurt. No citations were issued to either driver.

A total of nine other accidents occurred on the project. Six of these were vehicle accidents and the remainder were minor personal injuries. These accidents occurred with an exposure period of over 60,000 man-hours worked and over 200,000 miles driven, in rough country with primitive roads and under extremely hazardous working conditions. It is felt that this better than average record was due to the emphasis placed on safety.

VII. PUBLIC INFORMATION

Two full-time information officers were assigned to the project to cover the informational and public relations aspects, one from the Forest Service and one from the Washington State Department of Natural Resources.

Landowners of record with property recorded within the treatment area, were notified by letter of the upcoming project before spraying began and were provided an estimate of their costs. Many news releases were sent in advance of the project to newspapers throughout the States of Washington and Oregon

with complete information on the project including approximate treatment dates.

Public notices were posted in post offices, public buildings, and other locations likely to be visited by the general public. Public agencies likely to have an interest in the project were notified.

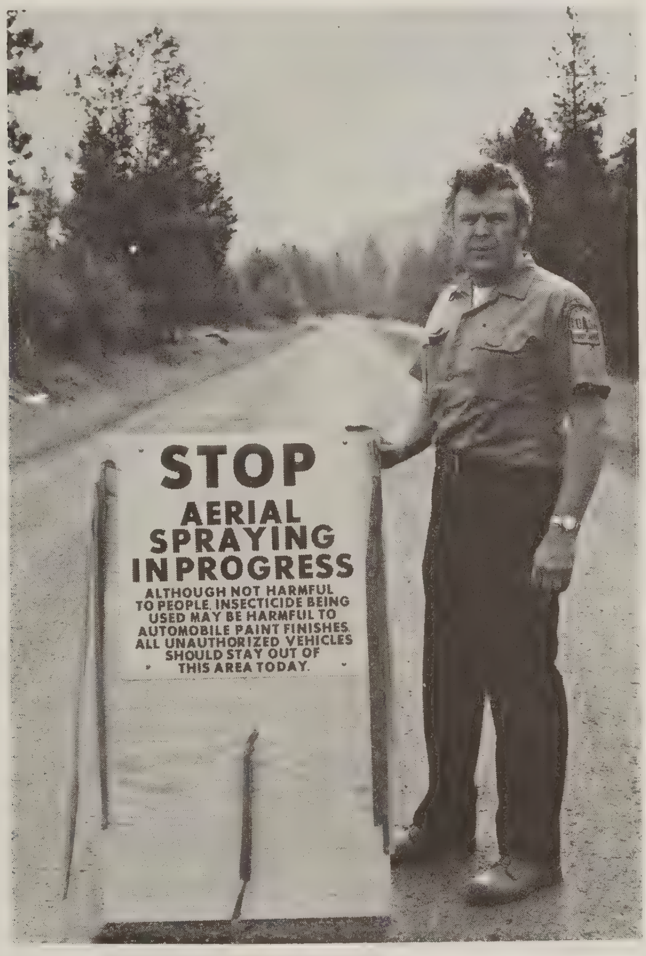
Printed fact sheets with updating amendments were provided to public agencies, private landowners, news media, and other interested persons and organizations. They were also used for handouts for the general public at key locations such as Ranger Stations, Forest Supervisor's Offices, project offices, and other outlets.

During the project, daily contact was made with news media personnel on current status of the spraying. In addition, news releases were sent out periodically for current information on spraying. Radio and television scripts were provided and tapes of project activities were sent to radio and television stations.

Show-me trips were held for the news media and officials of public and private organizations, explaining the project activities. Slide shows and other presentations were made to civic clubs, schools, and other organizations within and adjacent to the project area.

Notices of spraying and possible damage to vehicle paint from the insecticide were posted at all trail heads, campgrounds, and other public-use areas within the spray area. In addition, all forest users were notified personally of treatment dates and areas.

Daily status and progress reports were sent to news media, all National Forests in the Region, Regional Office, Washington Office, and other interested groups and individuals.



Signs were placed on roads leading into treatment areas to inform forest users that spraying was taking place.

VIII. ENVIRONMENTAL MONITORING

Due to the fact that malathion and Sevin 4 Oil have both been monitored extensively on other projects, monitoring on this project was limited to aquatic organisms, fish, water, birds, and bees. Monitoring of aquatic organisms, fish, and water was contracted to the Washington State Department of Ecology. Monitoring of birds and bees was carried out by project personnel.

Each Control Unit was assigned an Environmental Monitoring Coordinator whose principal duties were to provide information to monitoring personnel on current spraying plans, coordinate monitoring of accidental pesticide spills, coordinate damage claims investigation, inspect operational areas and procedures to insure that undue environmental contamination was avoided, provide information relating to the monitoring program to visiting scientists, and determine drift into nonspray areas.

Except for a temporary heavy kill of aquatic insects in streams sprayed directly with malathion, effects on aquatic insects, fish, and birds were negligible. No bees were available in spray areas to monitor. The few beekeepers who had hives adjacent to the treated area moved their hives before spraying. No known domestic bee-kill occurred.

Two bird transects were installed on each of the three Control Units. No distressed or dead birds were found on the transects. In addition, all project personnel were to report distressed or dead birds in the spray areas. No distressed or dead birds were observed. Following is a description of methods and results of monitoring efforts:

A. Aquatic Monitoring

The Washington State Department of Ecology was contracted to monitor pesticide residues in the aquatic environment and to conduct impact studies on the effects of the aerial spray project on aquatic organisms. The report on aquatic monitoring results is listed in the references.

1. Methods

a. Sampling Locations

Biological impact and chemical residue sampling were conducted on two index streams in each of the three major malathion spray units and in the Sevin 4 Oil spray block, totaling eight index streams. Control streams were designated during the prespray sampling. When possible, five sampling stations were established on each stream monitored. The first station was located within the spray area boundary; the four remaining stations were established below the boundary at approximately 1 mile intervals. Due to the extreme gradient of the streams on Goat Peak and the short distance to the Methow River, only three stations were designated on Yellow Jacket and Gate Creeks. Adequate control stations were established on nonsprayed streams.

b. Sampling Schedule

The prespray sample was taken within 1 week prior to spray application. Sampling on spray day began at 0000 hours and continued for 12 to 14 hours thereafter. On most index streams postspray sampling was completed within 48 hours after spray day.

c. Sampling Procedures

Sampling procedures addressed four aspects of environmental sampling: Residue and biological sampling, stream surveys, and water quality chemistry. Most of the water quality, biological, and residue samples were collected at the highest and lowest Stations; however, in some cases all five stations could not be established or sampling was impractical. In such cases, some modifications were made in designating the downstream sampling station.

2. Conclusions of Aquatic Monitoring

From the data gathered during the 1976 Spruce Budworm Control Project Monitoring Study, it was concluded that there was a pronounced increase in aquatic insect activity resulting from the introduction of malathion and Sevin 4 Oil into the aquatic environment. The impacts appeared to be relatively greater on the small streams than those of greater flow. Sevin 4 Oil imposed greater stress on the aquatic biota than did malathion.

Damage to the watercourses was considered minimal. Judging from insect live box studies and the Hansel Creek benthic samples, the impacts were primarily confined to the application area and about 2 miles downstream. Sufficient representation of all insect orders remained in the streams to provide full population recovery within a reasonable period of time. No fish mortalities were noted in the wild; however, fish mortalities did occur in the Gate Creek live boxes where Sevin 4 Oil was applied. Although the cause of the mortality was not determined, the Gate Creek spray block was large enough to cause a continuous exposure of the fish to the pesticide for an extended period.

For more detailed information on methods used and results of pesticide residue and impact monitoring on the aquatic environment, refer to Department of Ecology Monitoring Report in the list of references.

B. Bird and Bee Monitoring

Monitoring for effects of chemicals on birds and bees was carried out by project personnel under the direction of Unit Environmental Monitoring Coordinators.

1. Methods

Survey lines for bird monitoring were laid out in small drainages with some water flow and consisted of a U-shaped transect line intersecting the stream at right angles and with each arm of the transect measuring 10 chains in length. The survey strip consisted of an area of 4 feet on each side of centerline. All ground in the strip was carefully examined for dead or distressed birds. Arrangements were made to pack any birds found in dry ice and ship them immediately to the University of California at Davis for analysis.

Observers spent at least 2 hours examining other areas in the same way on each visit to the transect. These visits were made to the transects 12 to 24 hours before treatment, on the afternoon of the day of spraying, 24 hours after treatment, and 48 hours after treatment. In addition, all personnel on the project were instructed to watch for dead or distressed birds in spray areas and report any found.

The monitoring plan called for collection of six specimens of the same species of bird as any found dead or distressed, as a control. However, this did not become necessary since no dead or distressed birds were found that could be attributed to the use of insecticides.

The bee monitoring required counts of dead bees at hives that were within 3 miles of spray areas. Counts were to be made within 24 to 48 hours prior to spraying to determine the normal death rate. Postspray counts were to be made at 1, 3, and 5 days postspray to determine losses due to the insecticide.

A diligent search to locate bee hives was carried out by project personnel with generally negative results. Several hives were found outside the spray area but inside a 3-mile buffer zone established for additional protection. The owners of the hives removed their hives from proximity to the spraying when notified of the proposed treatment. No bee hives were found in or adjacent to the spray area that might have been subjected to the insecticide.

Results of monitoring for birds and bees were negative.

IX. TREATMENT EFFECTIVENESS

A. Methods

The effectiveness of the 1976 Western Spruce Budworm Project was determined by four methods. Standards to be attained, if the project was to be considered successful, were established for each method in the work plan (U.S. Forest Service, 1976) for the project.

The first method was a measurement of the budworm population density present in treated areas 14 days after insecticide application. Budworm counts of less than three larvae or one pupae per 100 new shoots were to be considered adequate control. This population is below any that has been previously recorded where resurgence to epidemic numbers followed a control project.

The second method of measuring effectiveness was a determination of the percent of population reduction between prespray and postspray population counts. A 90 percent unadjusted population reduction was to be considered fair control, 95 percent good, and 98 percent or greater, excellent.

The third method was a determination of the new budworm egg masses deposited in the control area during the fall following treatment. Control was to be considered adequate if the egg mass density did not exceed four per 1,000 square inches of foliage.

The final method of measuring effectiveness was to be a determination of the degree of defoliation that occurred during the 1976 and 1977 larval feeding periods. A 30 percent reduction in defoliation treated areas as compared to untreated areas was to be considered satisfactory control. Treated areas with less than 15 percent defoliation during 1977 and not visible during the 1977 aerial surveys was to also be considered successful control.

1. Budworm Population Counts

Pre- and postspray budworm populations measured within 3 days prior to insecticide application and again 14 days after the application are given in Table 1. Population estimates were based on counts of budworm larvae or pupae per 100 buds. Covariance analysis was used to account for natural mortality. Results using Abbotts formula are included for comparison.

Table 1. —Changes in budworm populations on treated and untreated study plots during a 14-day period following aerial application of insecticides.

Unit	Budworm Per 100 Buds		Percent Budworm Mortality		
	Prespray	Postspray	Unadjusted	Covariance	Abbotts
Ellensburg Malathion	48.1	7.2	83.5	72.4	70.6
Wenatchee Malathion	27.9	4.9	80.8	73.6	66.5
Okanogan Malathion	30.7	5.3	82.2	61.6	60.0
All Malathion	33.3	5.9	82.3		64.2
Okanogan Sevin 4 Oil	33.5	1.1	96.2	93.6	92.2
Checks	41.6	20.5	44.1		

The average number of larvae or pupae per 100 buds surviving 14 days after insecticide application with malathion exceeded the standard of three larvae or one pupae per 100 buds estab-

lished as necessary for successful control on all areas treated. The area treated with Sevin 4 Oil had a residual population of only 1.1 larva per 100 buds, well within the minimum satisfactory control standards.

2. Budworm Population Reduction

The percentage of reduction in the budworm population during a 14-day period following treatment as shown in Table 1 did not reach the minimum acceptable level of control on any of the malathion-treated areas. The area treated with Sevin 4 Oil had a 96.2 percent unadjusted population reduction which was above the 95 percent level established as necessary for good control.

3. Egg Mass Surveys

A budworm egg survey was made on treated and untreated areas during the fall of 1976. Some treated areas were relatively free of new eggs while others still contained large numbers of new egg masses (Table 2). Egg counts were much higher on most untreated areas.

Evaluation of the egg survey data on an individual spray block basis showed less than four new egg masses per 1,000 square inches of foliage on 226,000 acres of the 365,000 acres treated during the 1976 control project. On the Goat Peak Subunit, which had been treated with Sevin 4 Oil, new egg masses numbered only 1.4 per 1,000 square inches and only two of the 26 evaluation clusters exceeded four per 1,000 square inches of foliage.

Table 2. —New budworm egg masses per 1,000 square inches of foliage on control project units during fall of 1976.

Unit	Subunit	No. Plots	Egg Masses Mean	Egg Masses Range	No. Plots Without Eggs
Malathion					
Okanogan					
	Twisp	26	5.4	0.0-13.5	1
	Winthrop	26	4.4	0.0-27.1	6
	Mazama	26	4.1	0.0-13.9	2
	Winters	24	2.8	0.0-27.9	5
	Checks (untreated)	26	9.3	0.0-31.4	1
Wenatchee					
	Nason	26	1.4	0.0- 6.2	6
	Icicle	26	3.1	0.0-14.1	2
	Chiwawa	26	2.9	0.0- 2.0	19
	Checks (untreated)	26	8.4	0.0-52.3	1
Ellensburg					
	Teanaway	26	3.7	0.0-30.6	7
	Taneum	26	7.3	0.0-51.4	1
	Swauk	26	5.5	0.0-37.6	1
	Warm Springs	26	2.7	0.0- 7.9	2
	Checks (untreated)	26	7.8	1.5-45.5	0
Sevin 4 Oil					
Okanogan					
	Goat Peak	26	1.4	0.0- 5.7	4

4. Defoliation

Prespray budworm populations were high on all treated and untreated areas and extensive defoliation from larval feeding occurred before the insecticide was applied. Application of the short-life insecticide was timed so the buds would be open and the budworm would be feeding in locations where they could readily be contacted by the insecticide.

The goal of saving 30 percent of the current year's foliage was attained on only one Subunit (see Table 3). Very little foliage was saved on those Subunits where the prespray population counts exceeded 30 per 100 buds.

Major savings in foliage are expected in 1977 on those areas where the population was reduced to four or fewer egg masses per 1,000 square inches of foliage. To determine if this actually occurs, an additional defoliation survey, identical to the 1976 survey, will be made during August 1977.

Table 3. — Prespray and postspray budworm populations and resulting defoliation compared with defoliation on untreated plots.

Unit	Subunit	Budworm Population Prespray	Budworm Population Postspray	Percent Defoliation	Standard Error	Percent Foliage Saved
Malathion						
Ellensburg						
	Teanaway	52.8	6.6	92.7	±1.7	0.0
	Taneum	45.1	8.9	90.1	±2.5	0.3
	Swauk	43.1	6.9	90.8	±2.6	0.0
	Warm Springs	39.4	4.2	98.4	±0.3	0.0
	Checks (untreated)	45.6	23.0	90.4	±3.6	—
Wenatchee						
	Icicle	33.4	8.1	68.4	±5.4	15.8
	Nason	39.4	5.1	70.1	±6.1	13.7
	Chiwawa	20.8	1.6	49.4	±6.4	39.2
	Checks (untreated)	40.3	21.4	81.2	±4.0	—
Okanogan						
	Twisp	39.4	8.6	73.2	±4.4	4.9
	Winthrop	26.3	4.6	63.7	±5.5	17.2
	Mazama	26.3	3.3	61.8	±5.8	19.7
	Winters	29.4	4.3	65.0	±6.2	15.5
	Checks (untreated)	33.1	14.2	76.9	±4.5	—
Sevin 4 Oil						
Okanogan						
	Goat Peak	33.5	1.1	70.9	±4.6	7.8

B. Spray Deposition

Spray deposition in terms of droplet size, number of drops per square centimeter, and ounces of insecticide per acre was determined from the use of Sudan black spray deposit cards, manufactured especially for use with malathion. Two spray cards were placed at each sample tree on the treatment effectiveness evaluation plots, for a total of 702 spray deposit cards located throughout the project. Several thousand additional cards were installed in stream buffer zones and other critical areas to determine the amount of drift received in these areas.

During analysis of the cards it was discovered that there was a possible error in determining whether the smaller marks on the cards were flaws in the material or small drops of malthion. As a result, analysis of the spray deposit was done once by counting the smallest size category (less than 24 micrometers) and a second time by eliminating this category. The difference in ounces per acre was very small but the difference in number of drops was quite large.

The Sudan black cards used on the malathion portion of the project were not suitable for producing quantitative data and were unsatisfactory for recovering small droplets. An analysis of spray droplet size (VMD), drops per square centimeter, and mass of spray deposit failed to show any correlation with insect mortality. Complete spray deposit data can be found in the Appendix, Tables 11 through 13.

X. COSTS

Total project control costs were $1,696,853 or $4.64 per acre. A detailed summary of costs is shown in Table 5 of the Appendix. Costs were shared by State and Federal agencies and private landowners under authority provided in the Forest Pest Control Act of June 25, 1947, as Amended.

The Federal government paid the full control costs on Federal land and 50 percent of the costs on State and private land. The State of Washington paid 25 percent of the costs on private land and the remaining 50 percent of the costs on State land. Private landowners paid 25 percent of the costs on their lands.

XI. RECOMMENDATIONS FOR FUTURE PROJECTS

A critique of the project was held by project personnel when the project was completed. Some of the major recommendations that came out of this critique are as follows:

1. Because of the difficulty in seeing the 13-ounce per acre spray being dispensed from the spray booms, faster flying aircraft or beecomist nozzles should be used to permit more accurate monitoring by the aerial observers.

2. All aerial contractors should be required to provide chemical-resistant or neoprene hoses on all equipment. Most of the spills that occurred were caused by old rubber hoses.

3. A spray team should be developed to handle large spray projects. This would reduce the problems in getting managers to release competent and experienced personnel in the middle of the field season for spray projects.

4. A more intensive check of pilot qualifications for forest spraying needs to be done. Pilot qualification sheets furnished by contractors cannot always be relied on.

5. A full-time, highly qualified, helicopter specialist should be assigned to the project for training project personnel in helicopter safety and for inspecting heliports and helispots.

6. Some personnel from Ranger Districts in the project area should be assigned to the project to provide local knowledge of areas and potential problems and to provide liaison with District personnel.

7. A Public Information Officer should be assigned to each control unit on a full-time basis for about 2 weeks before and about 2 weeks after the project commences. This would relieve the load on unit management personnel in providing information, answering questions, and making talks to local organizations.

8. Construction of aerial markers should be contracted out and completed before the spraying commences.

9. In extremely rough topography, automatic relay radio equipment should be provided.

10. Calibration of aircraft should be carried out before they arrive on the project, whenever possible.

11. The number of aircraft on any one control unit should be limited to prevent air traffic control problems.

12. Consideration should be given to eliminating streamside buffer zones.

XII. REFERENCES

Carolin, V. M. and W. K. Coulter
1971 - Trends of western spruce budworm and associated insects in Pacific Northwest forests sprayed with DDT. J. Econ. Entomol. 64: 291-297, illus.

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1977 - Aquatic monitoring of the 1976 spruce budworm control project in Washington state. Office of Water Programs, Technical Report DOE 77-3. January 50 pp.

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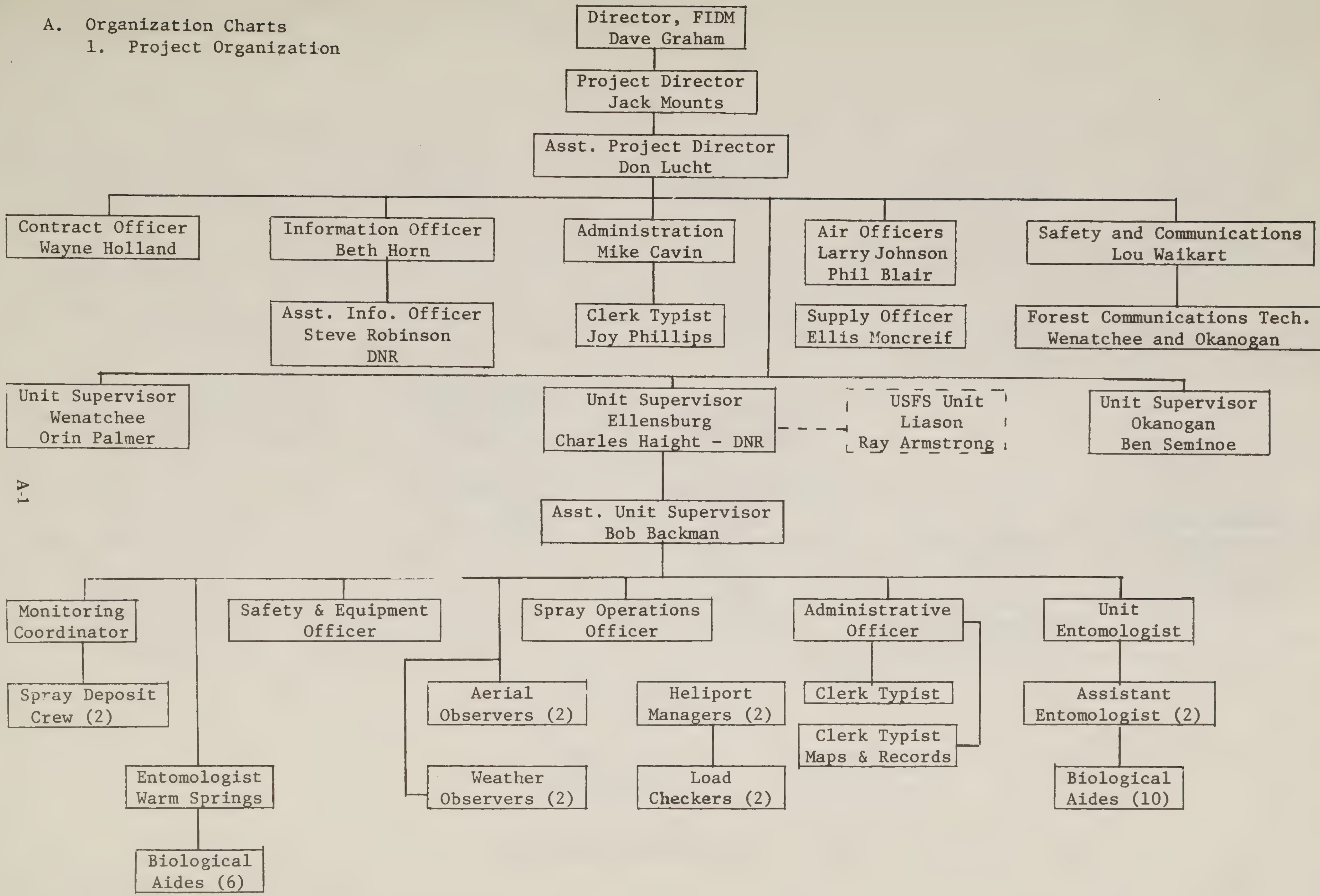
1976 - Project plans for the 1976 spruce budworm control project. Forest Insect and Disease Management, State and Private Forestry, Pacific Northwest Region. May. 96 pp.

U. S. Forest Service
1976 - Work plan for the timing of insecticide application and evaluating the efficacy of the 1976 western spruce budworm project. May. Portland, Oregon.

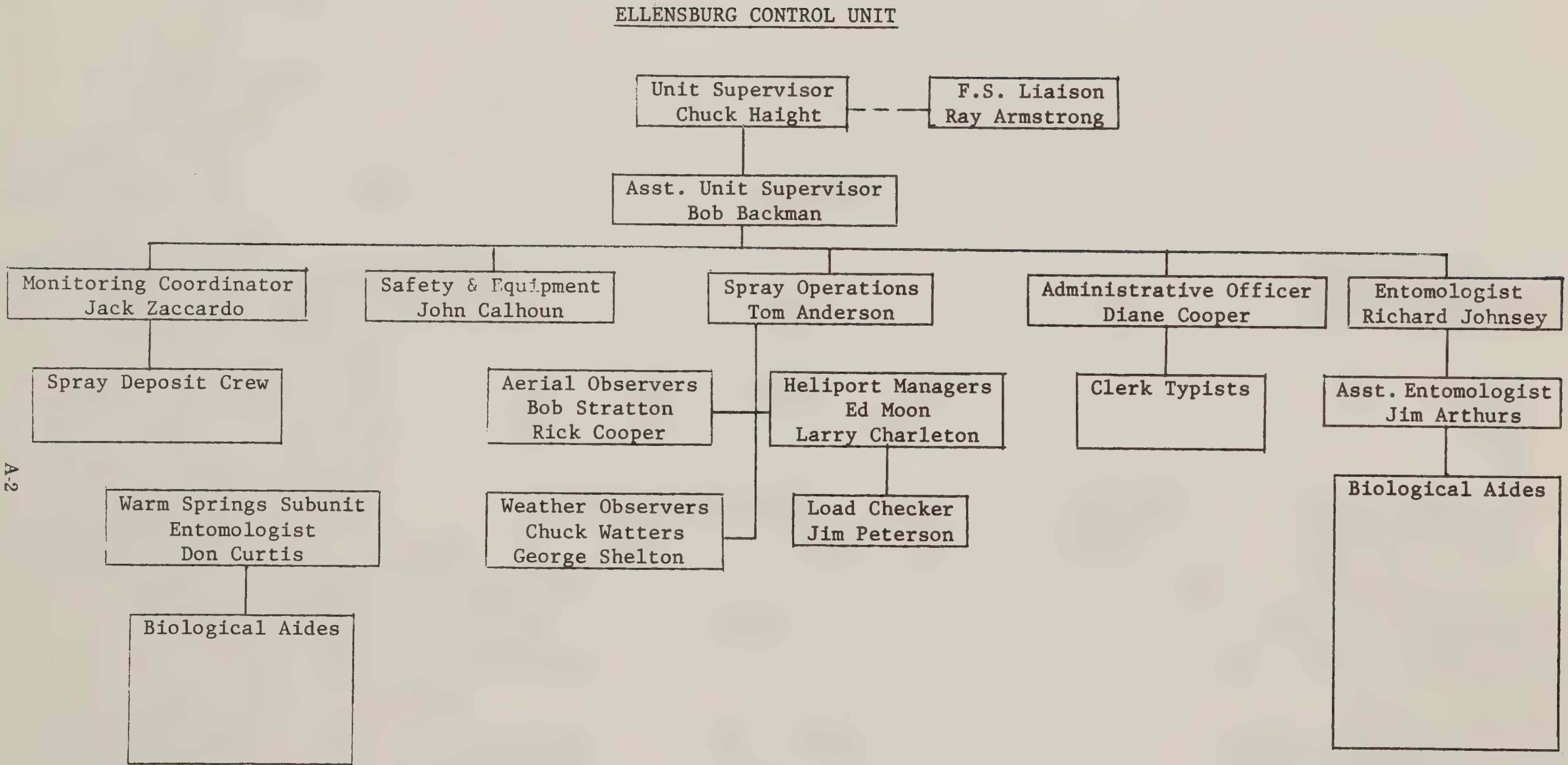
XIII. APPENDIX

A. Organization Charts

1. Project Organization



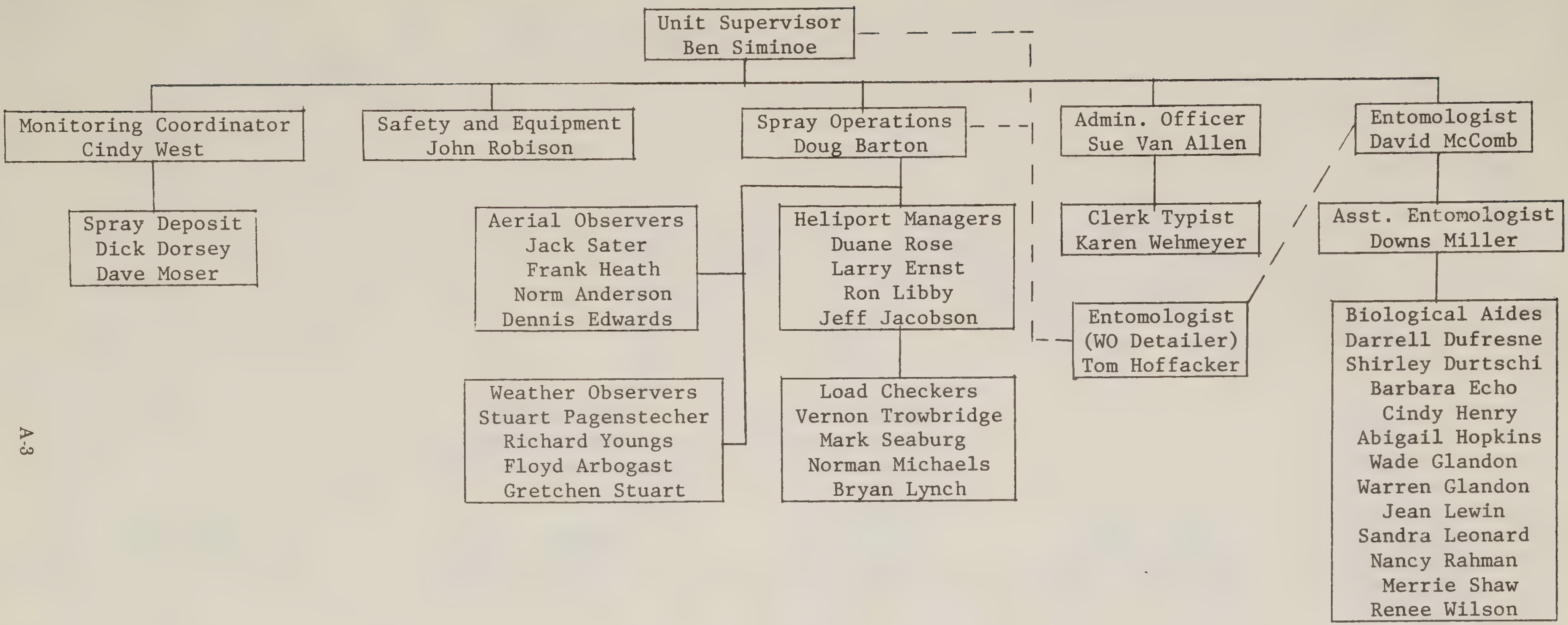
A. Organization Charts
2. Ellensburg Control Unit



A. Organization Charts

3. Okanogan Control Unit

OKANOGAN CONTROL UNIT



A. Organization Charts
   4. Wenatchee Control Unit

WENATCHEE CONTROL UNIT

- Unit Supervisor — Orin Palmer
  - Monitoring Coordinator — Bill Aldrich
    - Spray Deposit Crew — Ken Foster, Dave Moyer
  - Safety and Equipment — Ben Cottman
  - Spray Operations — Bill Selby
    - Aerial Observers — Dennis Pendleton, Bill Warner
    - Weather Observers — Virginia Busch, Mike Sewell
    - Heliport Managers — Tom Shimp, Joe Primm
      - Load Checker — Jon Markosky, Ernest Moser
  - Administrative Officer — Lou Petterson
    - Clerk Typists — Bobby Lindquist, Linda McMahon
  - Entomologist — Leon Pettinger
    - Asst. Entomologist — Dave Laws, Bob Acciavatti
      - Biological Aides

TABLE 4

ACREAGE TREATED BY OWNERSHIP

Oregon and Washington

Ownership	Acres	Percentage
Washington		
National Forest		
Okanogan	151,140*	
Wenatchee	156,070	
Subtotal	307,210	84.0
State	2,919	
Private	48,652	
Subtotal State & Private	51,571	14.1
Total Washington	358,781	
Oregon		
Warm Springs I.R.	6,921	1.9
Total Oregon	6,921	
GRAND TOTAL	365,702	

* *Includes 7,663 acres treated with Sevin 4 Oil.*

TABLE 5

SUMMARY OF COSTS

(Including both malathion and Sevin costs)

Malathion ULV Insecticide	$ 361,602
Transportation and Storage of Malathion	23,415
Application - 365,702 Acres	358,484
Observation and Administrative Aircraft	319,271
Salaries	327,910
Per Diem	74,186
Transportation	46,134
Supplies, Materials, and Freight	41,437
Rents, Communications and Utilities	6,644
Environmental Monitoring	30,424
Laboratory Analysis of Monitoring Samples	10,284
Miscellaneous (Spray Card and Data Analysis, Final Report, Critique, etc.)	18,851
Washington State Department of Natural Resources Overhead Charge	19,394
TOTAL	$1,638,036

Total Malathion Cost/Acre = $1,638,036 ÷ 358,039 acres = $4.575/acre

Sevin 4 Oil Insecticide	$ 17,422
Application - 7663 acres at $2.10/acre	16,092
Observation and Administrative Aircraft	6,085
Salaries	7,492
Per Diem	1,880
Transportation	847
Supplies, Materials, and Freight	1,455
Rents, Communications, and Utilities	213
Environmental Monitoring	5,076
Lab Analysis of Monitoring Samples	1,716
Miscellaneous Expenses	539
TOTAL	$ 58,817

Total Sevin 4 Oil Cost/Acre = $58,817 ÷ 7,663 = $7.675

Overall Cost/Acre = $1,696,853 ÷ 365,702 = $4.64

Federal Government Costs	$1,577,208
State and Private Costs	119,645
TOTAL	$1,696,853

TABLE 6

TREATMENT SUMMARY

MALATHION

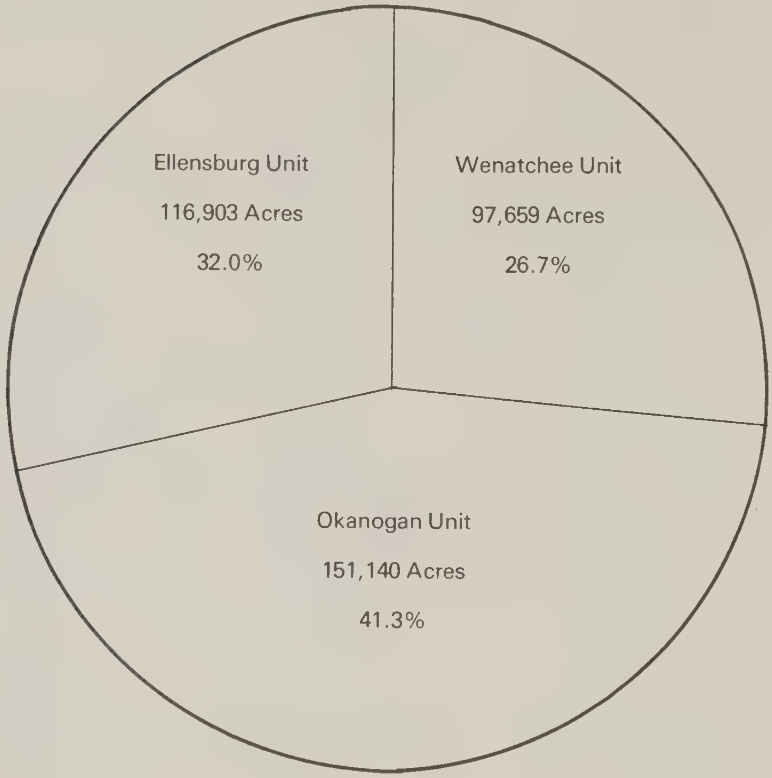
Date	Ellensburg	Okanogan	Wenatchee	Total
6/27	Nothing released	Nothing released	1,473	1,473
6/28	Nothing released	Nothing released	Nothing released	0
6/29	2,303	Nothing released	5,967	8,270
6/30	Rain	788	Rain	788
7/1	Temperatures too cold for treatment			0
7/2	5,132	3,441	9,856	18,429
7/3	4,058	1,079	Rain	5,137
7/4	3,985	5,995	Nothing released	9,980
7/5	5,497	7,622	Nothing released	13,119
7/6	5,456	8,842	3,810	18,108
7/7	1,527	4,338	1,664	7,529
7/8	2,106	Rain	Rain	2,106
7/9	5,710	12,140	9,137	26,987
7/10	4,963	14,026	8,615	27,604
7/11	10,282	No contractor	5,938	16,220
7/12	6,833	Wind	4,067	10,900
7/13	15,272	3,309	8,044	26,625
7/14	15,933	10,586	9,915	36,434
7/15	9,604	13,722	Resting Pilots	23,326
7/16	12,934	8,596	9,935	31,465
7/17	No chemical*	7,714	11,136	18,850
7/18	No chemical*	11,830	8,102	19,932
7/19	No chemical*	11,510	Unit completed	11,510
7/20	No chemical*	2,531	Unit completed	2,531
7/21	Wind	7,886	Unit completed	7,886
7/22	3,075	7,522	Unit completed	10,597
7/23	Unit completed Except for test area	Unit completed	Unit completed	0
7/24	2,233 (Thorp Creek Test)	Unit completed	Unit completed	2,233
Sub Totals	116,903	143,477	97,659	358,039

SEVIN 4 OIL

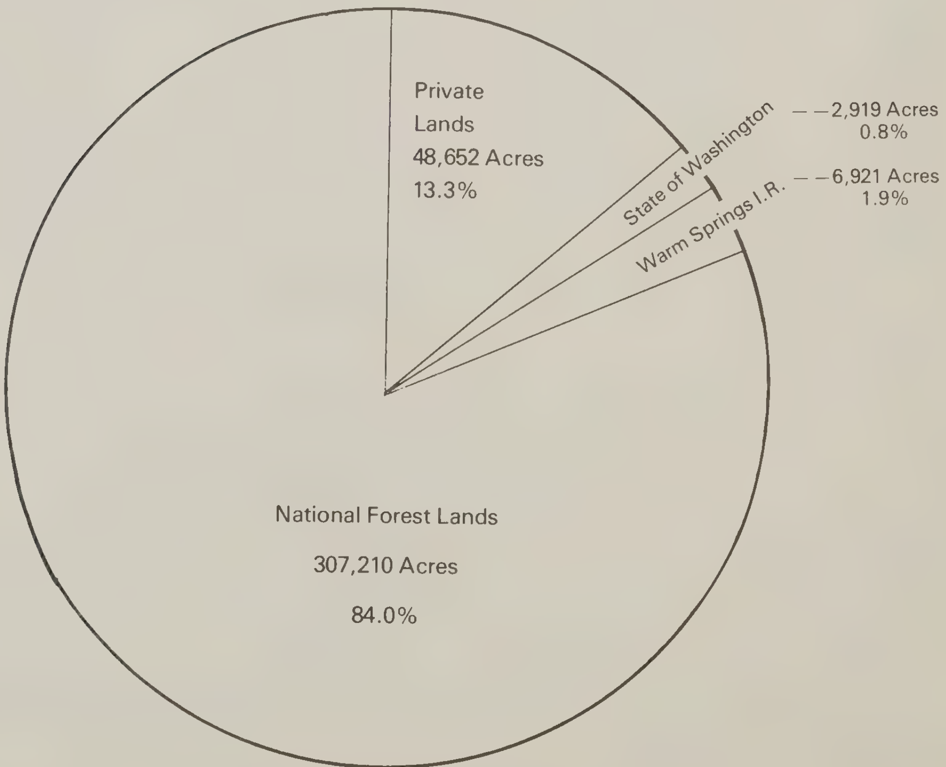
Date	Ellensburg	Okanogan	Wenatchee	Total
7/11		650		650
7/15		2,013		2,013
7/16		1,942		1,942
7/17		1,583		1,583
7/18		1,475		1,475
Sub Totals		7,663		7,663
TOTALS	116,903	151,140	97,659	365,702

* *Original chemical order ran out. More chemical was ordered but not received in time for use on the Ellensburg Unit until 7/21.*

CHARTS OF ACREAGES AND OWNERSHIPS



ACRES SPRAYED BY CONTROL UNIT



ACRES SPRAYED BY LAND OWNERSHIP

TABLE 7

PRODUCTION AND FLIGHT HOURS OF AIRCRAFT BY CONTROL UNITS

Control Unit	Total Acreage Sprayed	Total Days Available From Starting Day	Spray Days Available	Average Production Per Day Available	Average Production Per Spray Day	Average Production Per Flight Hour	Total Flight Hours For Spray Aircraft	Total Flight Hours For Observation Aircraft	Average Flight Hrs/Day
Ellensburg	116,903	27	18	4,330	6,495	590	198.0	279.5*	3.7
Okanogan	151,140	23	19	6,571	7,955	745	202.8	302.4	2.8
Wenatchee	97,659	22	14	4,439	6,976	626	155.9	328.9†	3.5
Project Headquarters								90.7	
Totals	365,702	72	51	5,079	7,171	657	556.7	1,001.5	3.3

* *Includes 62.5 hours on fixed-wing and 5.8 hours on Project Headquarters' ship and 6.1 hours on Wenatchee ship.*

† *Includes 64.8 hours on Project Headquarters' ship.*

TABLE 8

SUMMARY OF APPLICATION CONTRACTS

Contractor	Acres Treated	Cost/Acre	Total Cost*
Reforestation Services, Inc.	58,271	$ .86	$ 48,749.40
Western Helicopters, Inc.	131,169	$ .76	99,380.11
Mayfield Aviation	25,050	$.28 and $.68 †	8,701.19
Evergreen Helicopters, Inc.	85,206	$1.50	125,664.00
Cascade Helicopters, Inc.	58,343	$1.30	75,989.50
Hi-Life Helicopters ‡	7,663	$2.10	16,092.30
	365,702	$1.0243	$374,576.50

* *Reductions made for losses of insecticide.*

† *$.28 per acre for fixed-wing areas and $.68 for helicopter areas.*

‡ *Sevin 4 Oil area only.*

TABLE 9

SUMMARY OF SERVICE HELICOPTER CONTRACTS

Bid Item No.	Helicopters	Contractor	Days Guaranteed	Unit Price	Days	Hrs.	Final Payment
	Okanogan Unit						
1	2 light turbine-powered	Grote Aviation	30	$434.00/day $175.00/hr.	64	171.00	57,701
2	1 light turbine-powered	Corvallis Aero Service	15	$485.00/day $175.00/hr.	20	43.50	17,312
		Hi-Life Helicopters		$250.00/hr	5	24.34	6,085*
	Wenatchee Unit						
3	2 light turbine-powered	Mountain Air Helicopters	30	$495.00/day $175.00/hr.	58	169.10	58,302
4	1 light turbine-powered	Henderson Aviation	15	$525.00/day $175.00/hr.	24	86.90	27,808
	Ellensburg Unit						
5	2 light turbine-powered	Rambling Rotors, Inc.	30	$427.00/day $175.00/hr.	48	205.10	56,304
6	1 light turbine-powered	Corvallis Aero Service †	15	$485.00/day $175.00/hr.	20	63.60	20,782
	Project Headquarters						
7	1 light turbine-powered	Cascade Helicopters	15	$299.00/day $175.00/hr.	44.5	97.10	30,298
8	1 light turbine-powered without pilot	Aerocopters, Inc.	15	$450.00/day $160.00/hr.	42	64.20	28,902
	ADDITIONAL AIRCRAFT ADDED DURING THE PROJECT						
	1 light turbine-powered	Mountain Air Helicopters ‡	--	$495.00/day $175.00/hr.	5	14.20	5,100
	1 Cessna 182	Inland Aviation §	--	Flight time $ 40.00/hr. Standby time $ 10.00/hr.	13	62.50 (42.40)	3,079
					343.5	1,001.54	$311,673

* *Sevin 4 Oil Application — Separate Contract.*

† *This ship was used only on the Okanogan Unit.*

‡ *This ship was used on both the Wenatchee and Ellensburg Units.*

§ *This fixed-wing aircraft was used on the Ellensburg Unit.*

TABLE 10
PRODUCTION AND FLIGHT HOURS BY CONTROL UNIT, TYPE OF AIRCRAFT AND CONTRACTOR

Control Unit	Hiller 12E		Bell G3B & G3B-1		Bell 205A		Bell 206B		Snow & Ag-cat (Fixed Wing)		Total	
and Contractor	Hrs.	Acres	Hrs.	Acres	Hrs.	Acres	Hrs.	Acres	Hrs.	Acres	Hrs.	Acres
Ellensburg												
Mayfield Aviation	18.6	6,622							24.1	18,428	42.7	25,050
Western Helicopters			63.0	33,510							63.0	33,510
Cascade Helicopters			70.2	41,318			22.1	17,025			88.0	58,343
Sub-Totals	18.6	6,622	133.2	74,828			22.1	17,025	24.1	18,428	198.0	116,903
Okanogan												
Reforestation Services	125.6	58,271									125.6	58,271
Evergreen Helicopters	13.7	5,337			51.8	79,869					65.5	85,206
Hi-Life Helicopters	3.3	1,689					8.4	5,974			11.7	7,663
Sub-Total	142.6	65,297			51.8	79,869	8.4	5,974			202.8	151,140
Wenatchee												
Western Helicopters			155.9	97,659							155.9	97,659
Totals	161.2	71,919	289.1	172,487	51.8	79,869	30.5	22,999	24.1	18,428	556.7	365,702
Production/Flight Hr. Acres	446.1		596.6		1541.9		754.1		764.6		656.9	
% of Total Production	19.7		47.2		21.8		6.3		5.0		100.0	

SPRAY DEPOSIT DATA

TABLE 11. —All Blocks - Malathion, All Size Categories. Block Means.

Unit/ Subunit	VMD (Micro-meters)	Drops/ cm^2	Mass (oz/ acre)	Unadjusted Mortality (Percent)	Residual Population (Insects/ 100 Buds)
Wenatchee					
Icicle	172.9	70.8	1.70	75.7	8.12
Nason	170.2	78.9	1.50	82.6	5.11
Chiwawa	176.5	82.7	2.60	92.2	1.63
Average	173.2	77.5	1.90	83.5	4.95
Ellensburg					
Teanaway	162.6	121.2	2.00	87.5	6.59
Taneum	157.9	81.3	1.60	82.6	5.11
Swauk	138.7	113.4	2.10	84.0	8.55
Warm Springs	278.3	45.7	2.90	89.3	4.20
Average	184.4	90.4	2.15	85.9	6.11
Okanogan					
Twisp	220.4	72.2	2.10	78.1	8.64
Winthrop	167.2	63.8	1.20	82.4	4.63
Mazama	185.4	50.2	1.60	87.5	3.29
Winters	182.2	47.0	1.50	85.3	4.52
Average	188.8	58.3	1.60	83.3	5.27
Average of All Subunits	182.9	75.2	1.90	84.3	5.49

SPRAY DEPOSIT DATA

TABLE 12. —All Blocks - Malathion

Excluding 1st Size Category

Unit/ Subunit	VMD (Micro- meters)	Drops cm^2	Mass (oz/ acre)	Unadjusted Mortality (Percent)	Residual Population (Insects/ 100 buds
Wenatchee					
Icicle	179.2	1.3	1.5	75.7	8.12
Nason	179.4	1.1	1.3	82.6	5.11
Chiwawa	181.6	2.3	2.4	92.2	1.63
Average	180.1	1.6	1.7	83.5	4.95
Ellensburg					
Teanaway	174.8	3.8	1.7	87.5	6.59
Taneum	171.8	1.6	1.4	82.6	5.11
Swauk	159.9	2.5	1.8	84.0	8.55
Warm Springs	282.6	1.9	2.8	89.3	4.20
Average	197.3	2.4	1.9	85.9	6.11
Okanogan					
Twisp	251.6	1.8	1.9	78.1	8.64
Winthrop	178.5	.8	1.0	82.4	4.63
Mazama	192.9	1.0	1.5	87.5	3.29
Winters	194.4	1.2	1.3	85.3	4.52
Average	204.3	1.2	1.4	83.3	5.27
Average of All Subunits	195.2	1.8	1.7	84.3	5.49

SPRAY DEPOSIT DATA

TABLE 13. —Goat Mountain Block—Sevin 4 Oil.

Cluster Averages of Mortality and Spray Deposit Data

Cluster	All Sizes Categories		Excluding First Category		Unadjusted Mortality Percent
	Drops/ cm^2	Mass (oz/acre)	Drops/ cm^2	Mass (oz/acre)	
1	4.40	4.30	.70	4.20	92.1
2	.70	5.60	.70	5.60	92.2
3	9.20	23.30	3.70	23.00	100.0
4	33.50	58.00	9.60	56.90	96.8
5	4.30	.70	.70	.60	100.0
6	2.80	6.90	2.80	6.90	99.0
7	6.70	1.80	1.20	1.60	80.6
8	3.00	.30	.20	.20	98.1
9	8.70	3.80	1.40	3.40	98.9
10	.50	6.00	.50	6.00	96.3
11	3.10	2.60	1.30	2.50	98.9
12	19.80	12.90	5.10	12.20	99.3
13	8.00	2.30	.60	2.00	99.2
14	5.20	6.70	1.60	6.50	100.0
15	.04	.01	.04	.01	97.2
16	.10	.10	.10	.10	89.6
17	36.70	1.70	.01	.01	97.7
18	30.10	22.90	4.40	21.70	97.5
19	5.20	15.40	3.40	15.40	93.5
20	13.60	20.30	7.90	20.10	94.7
21	6.11	12.10	4.30	12.00	100.0
22	2.00	.30	.10	.20	87.6
23	14.60	17.80	5.50	17.30	97.6
24	.30	.40	.30	.40	98.1
25	3.80	7.50	2.00	7.40	98.6
26	5.50	7.30	1.80	7.10	96.5
Average	8.50	8.90	2.20	8.60	96.7

TABLE 14

EFFECTIVENESS OF CONTROL

WESTERN SPRUCE BUDWORM CONTROL PROJECT — 1976

				Adjusted By	
Unit	**Pre**	**Post**	**Unadjusted Mortality**	**Covariance Mortality**	**Abbotts Mortality**
Ellensburg	48.14	7.15	.835	.724	.706
Wenatchee	27.88	4.95	.808	.736	.665
Okanogan	30.67	5.27	.822	.616	.600
Combined Malathion	33.26	5.87	.823	--	.642
Okanogan Sevin 4 Oil	33.47	1.12	.962	.936	.722
Combined Checks	41.62	20.51	.441	--	--

TABLE 15

RESULTS OF ANALYSIS OF VARIANCE AND COVARIANCE

Unit	Variable	F	C_1	C_2
Ellensburg	Pre	1.24	-.55	---
	Post	22.08**	-9.08**	---
	Covariance	21.82**	-9.10**	---
	Mortality	15.70**	7.74**	---
Wenatchee	Pre	6.07**	-3.26**	---
	Post	45.97**	-11.17**	---
	Covariance	35.43**	-10.12**	---
	Mortality	18.27**	7.03**	---
Okanogan	Pre	2.80*	-.56	.85
	Post	18.22**	-8.12	3.39**
	Covariance	18.31**	-8.34**	3.84**
	Mortality	20.48**	9.18**	-3.91**

Where F is the normal test statistic to test for equality of plot means, and C_1, C_2 are orthogonal contrasts. C_1 compares all treatments against the checks and C_2 compares Sevin 4 Oil against malathion. C_1 and C_2 are single degree of freedom contrasts—the values shown are T values.

* *Implies significance at the 95 percent level.*

** *Implies significance at the 99 percent level.*

Unstarred values indicate no significant difference between means.

TABLE 16

TABLE OF MEANS

WESTERN SPRUCE BUDWORM CONTROL PROJECT - 1976

Oregon and Washington

(WSBW Larvae Per 100 Buds)

Unit Subunit	N	Pre $\bar{x}$	 $SE\bar{x}$	Post $\bar{x}$	 $SE\bar{x}$	Adjust Post	Mortality
Ellensburg							
Teanaway	26	52.83	7.23	6.59	1.20	6.32	.860
Taneum	25	46.94	3.89	9.27	1.81	9.37	.791
Swauk	21	53.36	4.14	8.55	1.50	8.24	.811
Warm Springs	26	39.43	3.04	4.20	.78	4.80	.879
Ave. Malathion		48.14	2.42	7.15	.69	7.11	.835
Check	23	51.50	6.75	26.00	3.14	25.76	.407
Wenatchee							
Icicle	26	33.44	3.61	8.12	1.35	7.82	.733
Nason	26	29.36	3.13	5.11	1.11	5.31	.791
Chiwawa	26	20.83	2.38	1.63	.33	2.90	.901
Ave. Malathion		27.88	1.78	4.95	.59	5.34	.808
Check	26	40.31	3.89	21.36	1.82	20.20	.387
Okanogan							
Twisp	26	39.41	2.92	8.64	1.31	7.72	.787
Winthrop	26	26.31	2.16	4.63	.81	5.24	.822
Mazama	26	26.29	2.44	3.29	.58	3.91	.854
Winters	23	30.65	3.76	4.52	1.05	4.63	.821
Ave. Malathion		30.67	1.44	5.27	.49	5.38	.822
Goat Mountain	26	33.47	3.08	1.12	.23	.89	.962
Ave. Sevin 4 Oil		33.47	3.08	1.12	.23	.89	.962
Check	26	33.05	3.49	14.18	1.84	14.00	.529

Chart 2 - Mortality Chart

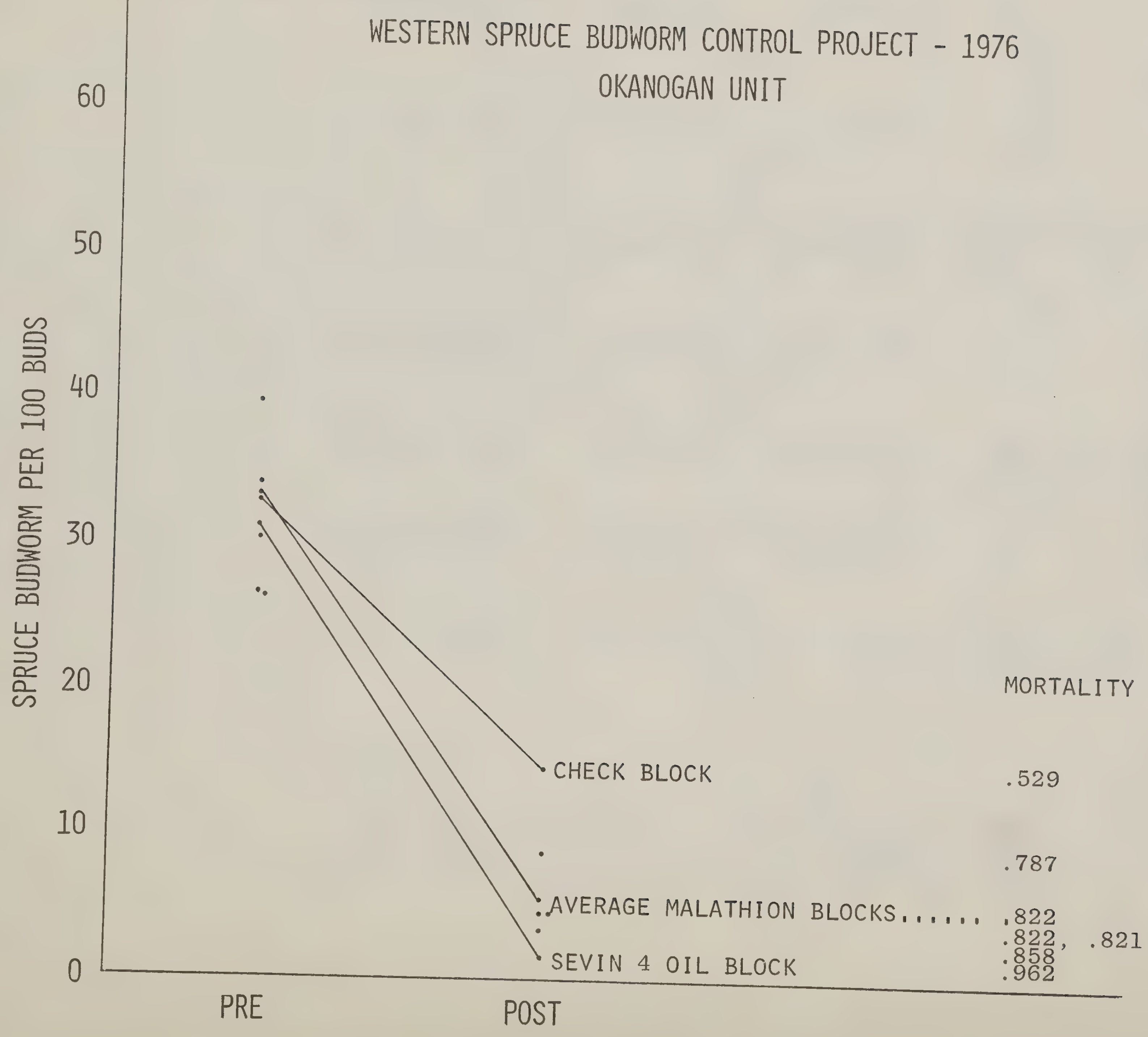


Chart 3 - Mortality Chart

WESTERN SPRUCE BUDWORM CONTROL PROJECT - 1976

WENATCHEE UNIT

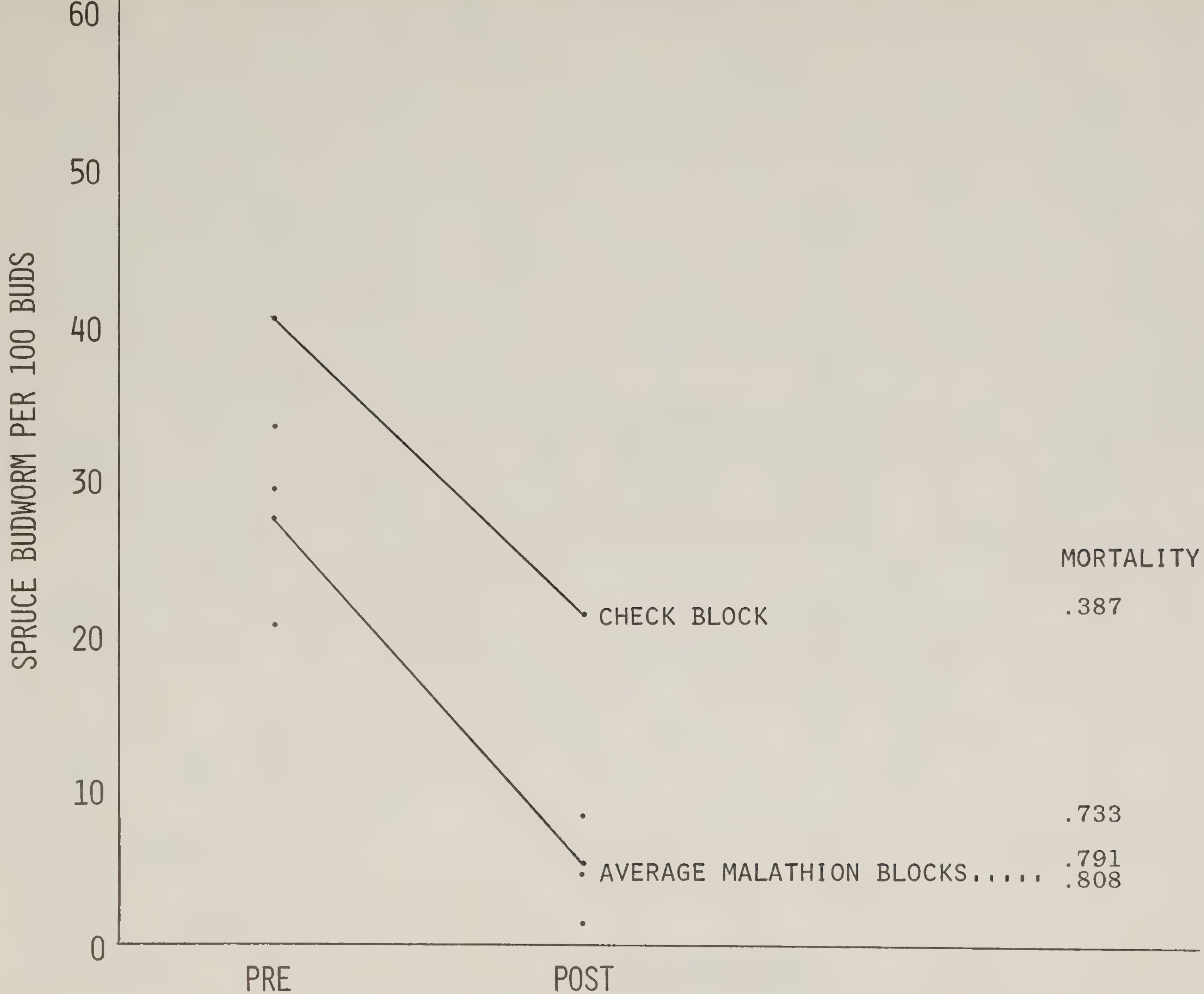
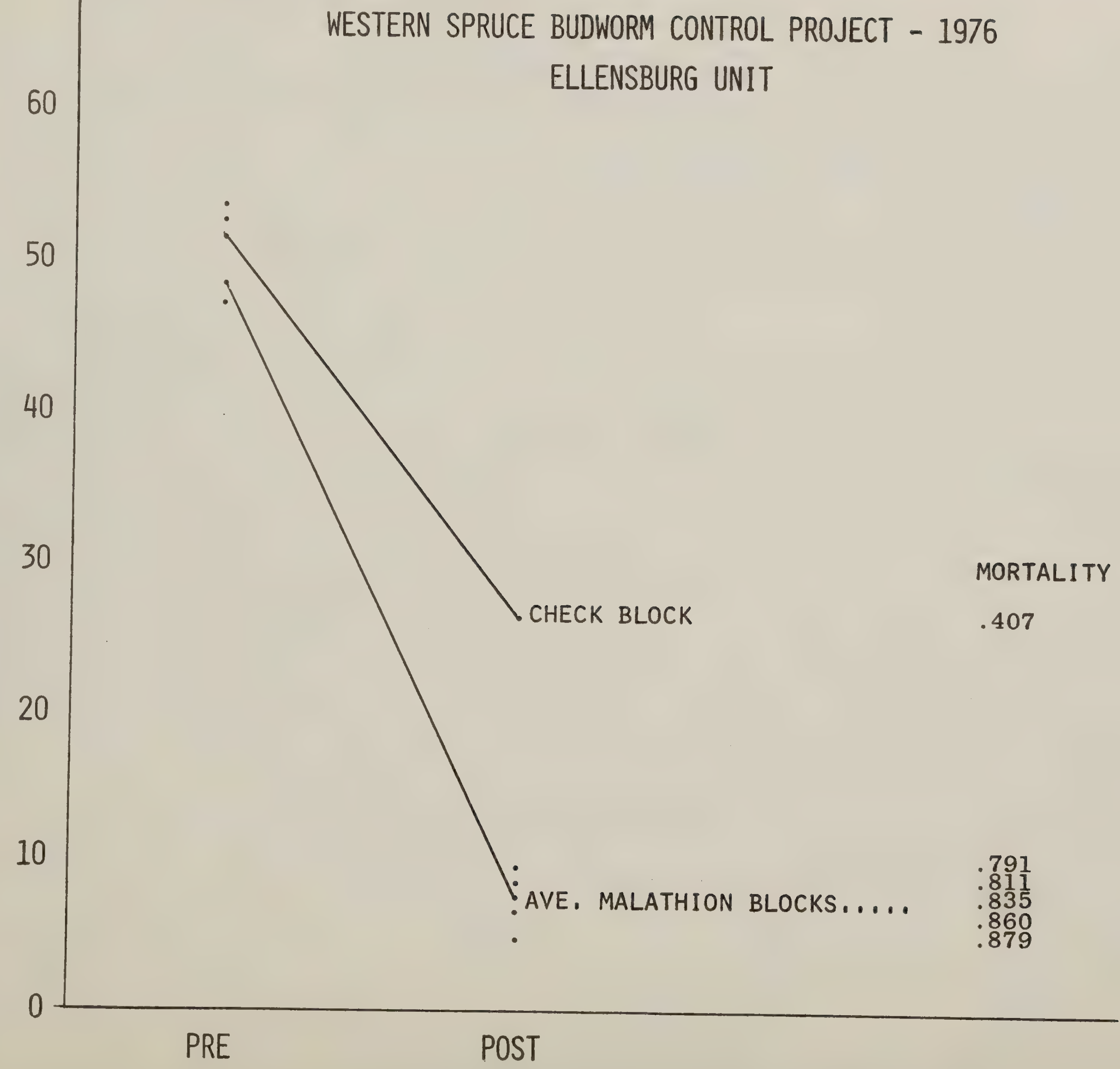
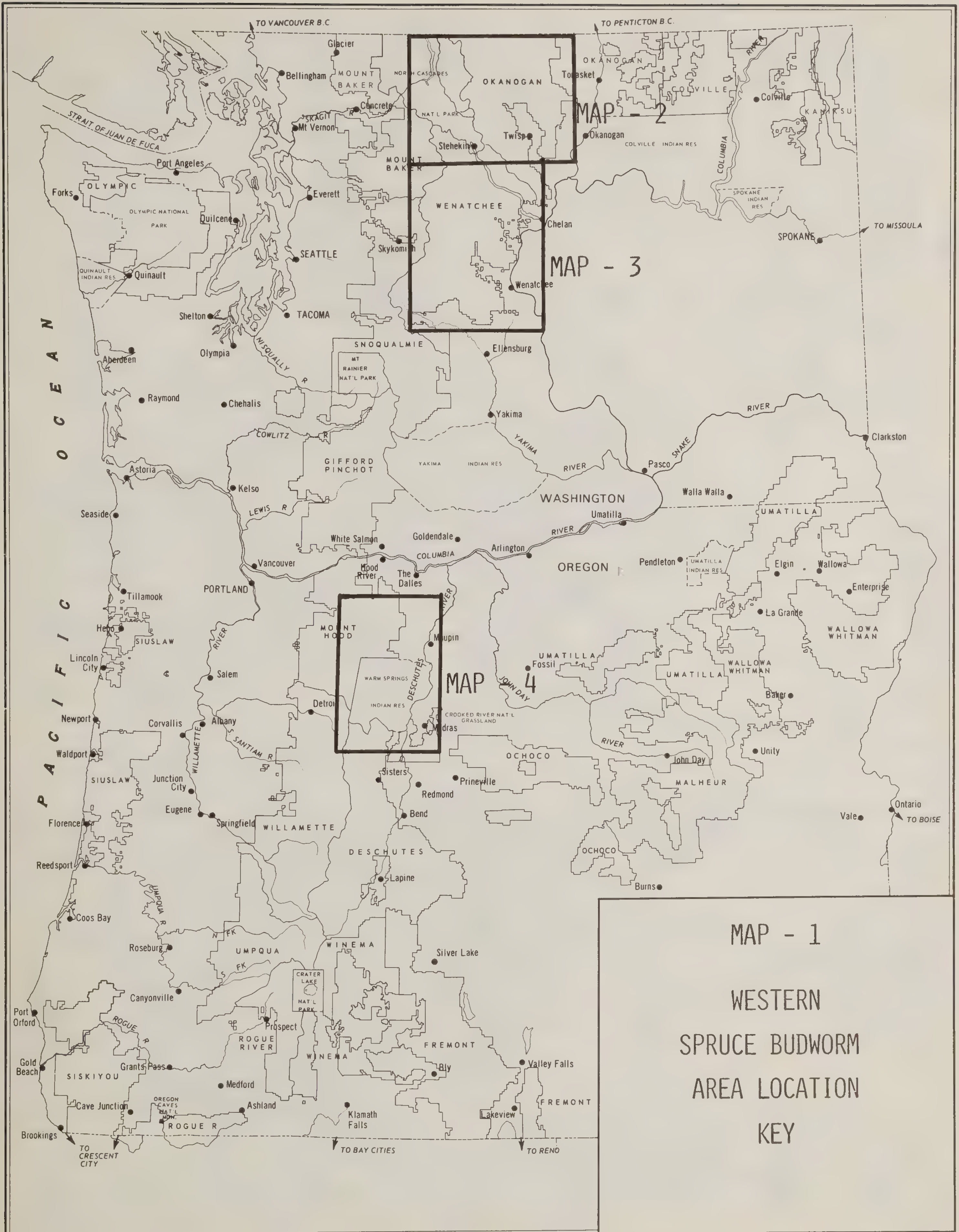


Chart 4 - Mortality Chart



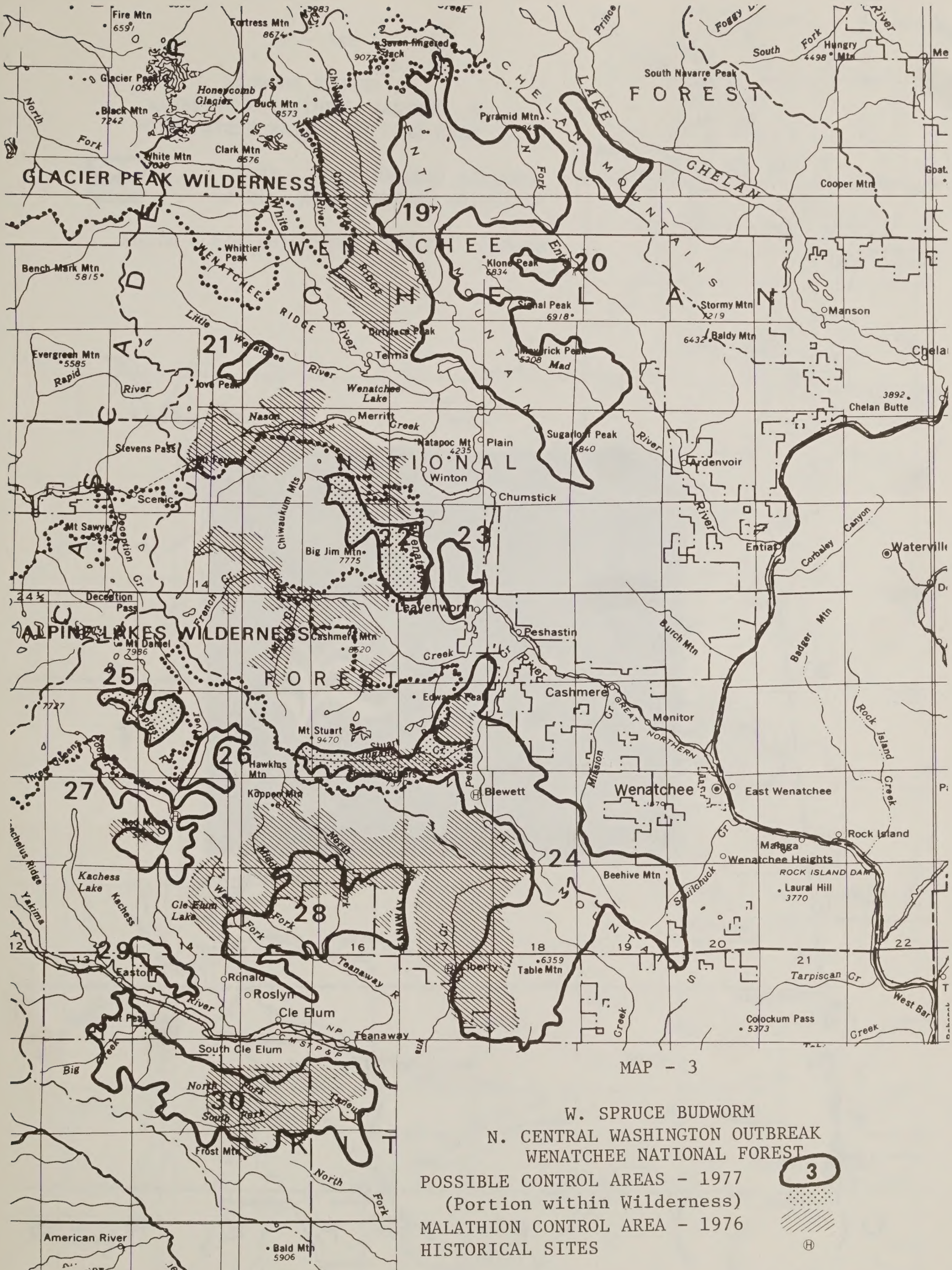

MAP - 1
WESTERN
SPRUCE BUDWORM
AREA LOCATION
KEY
MAP - 2
MAP - 3
MAP 4
PACIFIC OCEAN
WASHINGTON
OREGON
TO VANCOUVER B.C.
TO PENTICTON B.C.
TO MISSOULA
TO BOISE
TO RENO
TO BAY CITIES
TO CRESCENT CITY
STRAIT OF JUAN DE FUCA
OKANOGAN
WENATCHEE
COLVILLE
MOUNT BAKER
OLYMPIC
OLYMPIC NATIONAL PARK
QUINAULT INDIAN RES
SNOQUALMIE
MT RAINIER NAT'L PARK
GIFFORD PINCHOT
YAKIMA INDIAN RES
COLVILLE INDIAN RES
SPOKANE INDIAN RES
UMATILLA
UMATILLA INDIAN RES
WALLOWA WHITMAN
MOUNT HOOD
WARM SPRINGS INDIAN RES
CROOKED RIVER NAT'L GRASSLAND
SIUSLAW
WILLAMETTE
DESCHUTES
OCHOCO
MALHEUR
UMPQUA
WINEMA
CRATER LAKE NAT'L PARK
ROGUE RIVER
FREMONT
SISKIYOU
OREGON CAVES NAT'L MON
Bellingham
Glacier
Concrete
Mt Vernon
Tonasket
Okanogan
Colville
Twisp
Stehekin
Port Angeles
Forks
Everett
Quilcene
Chelan
SPOKANE
Skykomish
SEATTLE
Quinault
Wenatchee
TACOMA
Shelton
Olympia
Aberdeen
Ellensburg
Raymond
Chehalis
Yakima
Clarkston
Pasco
Astoria
Kelso
Walla Walla
Seaside
Umatilla
White Salmon
Goldendale
Arlington
Vancouver
Hood River
The Dalles
Pendleton
Elgin
Wallowa
Enterprise
PORTLAND
Tillamook
La Grande
Hebo
Maupin
Fossil
Lincoln City
Salem
Baker
Detroit
Madras
Newport
Corvallis
Albany
Waldport
Unity
John Day
Junction City
Sisters
Prineville
Redmond
Eugene
Springfield
Bend
Ontario
Vale
Florence
Reedsport
Lapine
Burns
Coos Bay
Roseburg
Silver Lake
Canyonville
Port Orford
Prospect
Gold Beach
Grants Pass
Valley Falls
Bly
Medford
Cave Junction
Ashland
Klamath Falls
Lakeview
Brookings
COLUMBIA
SNAKE RIVER
YAKIMA RIVER
COLUMBIA RIVER
COWLITZ R
LEWIS R
NISQUALLY R
SKAGIT R
SANTIAM R
UMPQUA R
ROGUE R
JOHN DAY RIVER
DESCHUTES RIVER

MAP - 2

W. SPRUCE BUDWORM
N. CENTRAL WASHINGTON OUTBREAK
OKANOGAN NATIONAL FOREST

POSSIBLE CONTROL AREA - 1977 (8)
(Portion within Wilderness)
MALATHION CONTROL AREA - 1976
SEVIN 4 OIL CONTROL AREA - 1976
HISTORICAL SITES

Scale: 1 inch = approximately 9.23 miles



MAP - 3

W. SPRUCE BUDWORM
N. CENTRAL WASHINGTON OUTBREAK
WENATCHEE NATIONAL FOREST

POSSIBLE CONTROL AREAS - 1977 (3)
(Portion within Wilderness)
MALATHION CONTROL AREA - 1976
HISTORICAL SITES Ⓗ

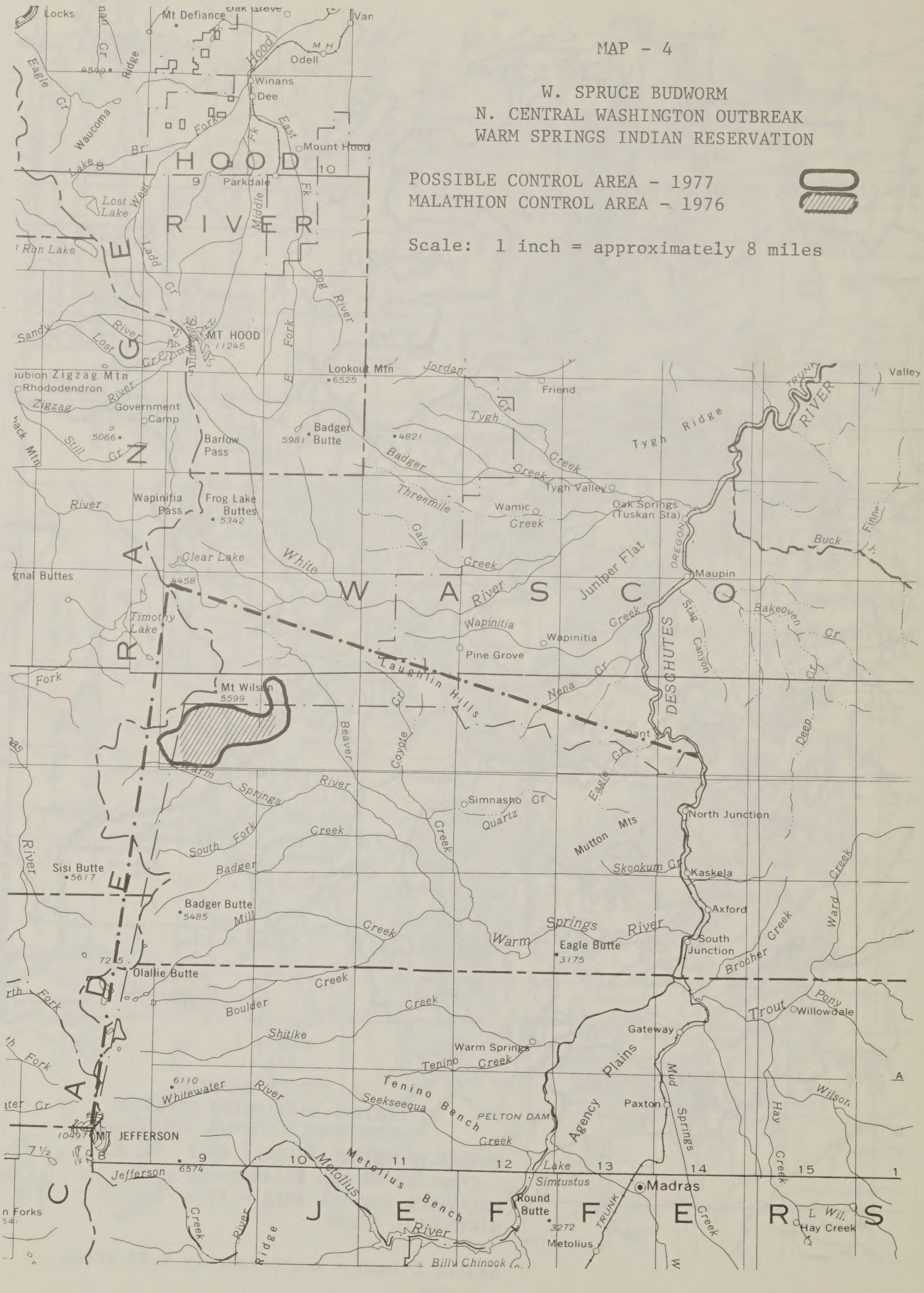
Scale: 1 inch = approximately 9.23 miles

MAP - 4

W. SPRUCE BUDWORM
N. CENTRAL WASHINGTON OUTBREAK
WARM SPRINGS INDIAN RESERVATION

POSSIBLE CONTROL AREA - 1977
MALATHION CONTROL AREA - 1976

Scale: 1 inch = approximately 8 miles



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